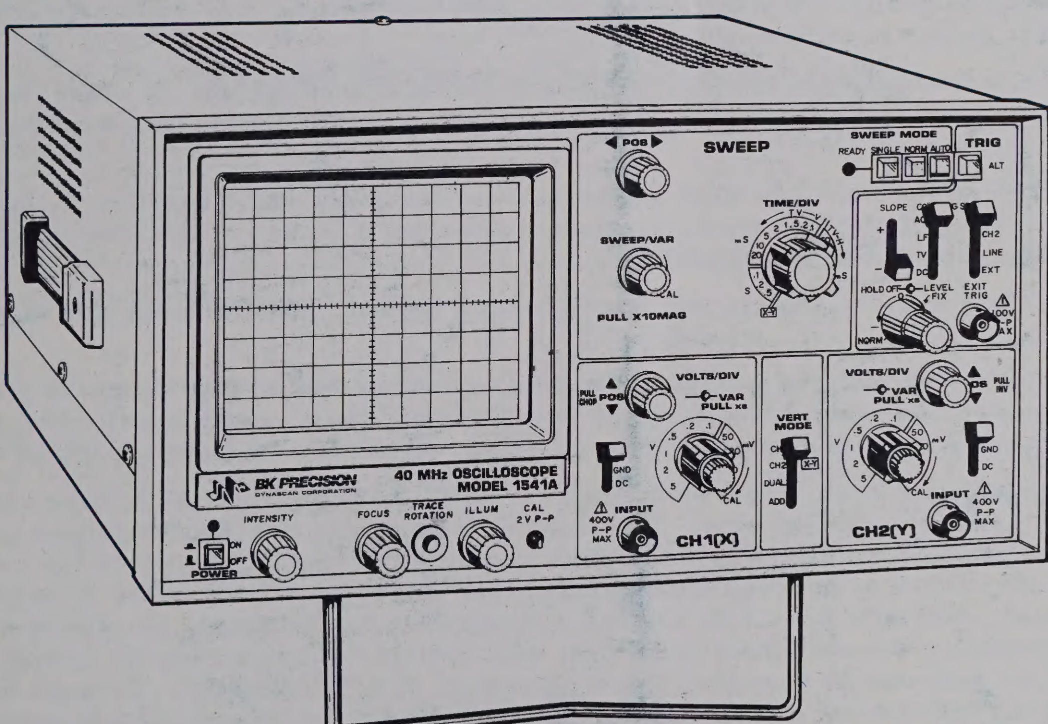
INSTRUCTION MANUAL

BK PRECISION
DYNASCAN CORPORATION

MODEL 1541A

07

40 MHz DUAL-TRACE OSCILLOSCOPE



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BK PRECISION
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TEST INSTRUMENT SAFETY

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed high voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly in the equipment under test. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.

2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.

3. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; make certain such surfaces are not damp or wet.

4. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.

5. When using a probe, touch only the insulated portion. Never touch the exposed tip portion.

6. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as the on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if the equipment is turned off.

7. Some equipment with a two-wire ac power cord, including some with polarized power plugs, is the "hot chassis" type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting the ground lead of most test instruments (including this oscilloscope) to a "hot chassis". To make measurements in "hot chassis" equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B & K-Precision** Model TR-110 or 1604 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis.

8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

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Instruction Manual

for

BK PRECISION
DYNASCAN CORPORATION

Model 1541A

40 MHz

Dual-Trace Oscilloscope

1541A 07

BK PRECISION
DYNASCAN CORPORATION

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FEATURES

HIGH FREQUENCY FEATURES

Wide Bandwidth
Conservatively rated -3 dB bandwidth is dc to 40 MHz.

Fast Rise Time
Rise time is less than 8.8 ns.

DUAL TRACE FEATURES

Dual Trace

Model 1541A has two vertical input channels for displaying two waveforms simultaneously. Selectable single trace (either CH 1 or CH 2) or dual trace. Alternate or chop sweep selectable at all sweep rates.

Sum and Difference Capability
Permits algebraic addition or subtraction of channel 1 and channel 2 waveforms, displayed as a single trace. Useful for differential voltage and distortion measurements.

CRT FEATURES

Rectangular CRT
Rectangular CRT with large 8 x 10 centimeter viewing area. Internal 8 x 10 division graticule eliminates parallax error.

Convenience
Variable scale illumination for easy viewing in darkened area and for waveform photographs. Trace rotation electrically adjustable from front panel. 0%, 10%, 90%, and 100% markers for rise time measurements.

VERTICAL FEATURES

High Sensitivity
5 mV/div sensitivity for full bandwidth. Selectable X5 gain increases maximum sensitivity to 1 mV/div at reduced bandwidth.

Calibrated Voltage Measurements
Accurate voltage measurements (±3%) on 10 calibrated ranges from 5 mV/div to 5 V/div. Vertical gain fully adjustable between calibrated ranges.

X5 Vertical Gain Magnification
X5 magnification control increases vertical sensitivity and adds 2 mV/div and 1 mV/div calibrated vertical attenuator ranges.

SWEEP FEATURES

Calibrated Time Measurements
Accurate (±3%) time measurements. Model 1541A has 20 calibrated ranges from 0.5 s/div to 0.2 μs/div. Sweep time is fully adjustable between calibrated ranges.

X10 Sweep Magnification
Allows closer examination of waveforms, increases maximum sweep rate to 20 ns/div.

TRIGGERING FEATURES

Five Trigger Modes
Selectable automatic, normal (triggered), FIX, X-Y, or single sweep modes.

AUTO Sweep
Selectable AUTO sweep provides sweep without trigger input, automatically reverts to triggered sweep operation when adequate trigger is applied.

Triggered Sweep
Sweep remains at rest unless adequate trigger signal is applied. Fully adjustable trigger level and (+) or (-) slope.

FIX Trigger Level
Trigger level is automatically fixed on center of waveform.

X-Y Operation
Channel 1 can be applied as horizontal deflection (X-axis) while channel 2 provides vertical deflection (Y-axis).

Single Sweep
Permits viewing and photographing one-time events.

Five Trigger Sources
Five trigger source selections, including ALT, CH 1, CH 2, LINE, and EXT. In ALT, each waveform displayed becomes its own trigger (alternate triggering in ALT dual-trace mode).

Four Trigger Coupling Choices
Selectable AC, LF (high-frequency reject), TV, or DC trigger coupling.

Video Sync
FRAME and LINE triggering automatically selected for observing composite video waveforms.

Variable Holdoff
Trigger inhibit period after end of sweep adjustable. Permits stable observation of complex pulse trains.

OTHER FEATURES

Z Axis Input
Intensity modulation capability permits time or frequency markers to be added. Trace blanks with positive signal, TTL compatible.

Built-In Probe Adjust Square Wave
A 2 V p-p, 1 kHz square wave generator permits probe compensation adjustment.

Channel 1 Output
Buffered 50Ω output of channel 1 signal available on rear panel for driving frequency counter or other instruments. Output is 50 mV/div into 50Ω and at full bandwidth rating.

Supplied With Probes
Oscilloscope comes with two identical 10:1/direct probes.

SPECIFICATIONS

CRT:

Model:
150BYB31.

Type:
Rectangular with internal graticule.

Display Area:
8 x 10 div(1 div = 1 cm).

Accelerating Voltage:
12 kV.

Scale Illumination:
Continuously adjustable.

VERTICAL AMPLIFIERS (CH 1 and CH 2)

Sensitivity:
5 mV/div to 5 V/div.
1 mV/div to 1 V/div, X5 gain selected.

Accuracy:
5 mV/div to 5 V/div, ±3%.
X5 gain selected, ±5%.

Input Resistance:
1 MΩ ±2%.

Input Capacitance:
Approximately 30 pF.

Frequency Response:
5 mV/div to 5 V/div (X5 gain not selected):
DC: DC to 40 MHz (-3 dB).
AC: 10 Hz to 40 MHz (-3 dB).
X5 gain selected:
DC: DC to 20 MHz (-3 dB).
AC: 10 Hz to 20 MHz (-3 dB).

Rise Time:
5 mV/div to 5 V/div (X5 gain not selected):
8.8 ns.
X5 gain selected:
17.5 ns.

Crosstalk:
At least 1000:1 (60 dB) at 50 kHz.
At least 30:1 (31.5 dB) at 40 MHz.

Operating Modes:
CH 1: CH 1, single trace.
CH 2: CH 2, single trace.
DUAL: dual trace.
0.5 s/div to 1 ms/div, CHOP.
0.5 ms/div to 0.2 μs/div, ALT.
CHOP or ALT selectable at any sweep rate.
ADD: algebraic sum of CH 1 + CH 2.

Chop Frequency:
Approximately 250 kHz.

Polarity Reversal:
CH 2 only.

Maximum Input Voltage:
400 V (dc + ac peak) or 400 V ac p-p.

HORIZONTAL AMPLIFIER
(Input through channel 1 input)

X-Y mode: switch selectable using TIME/DIV switch.
CH 1: X axis.
CH 2: Y axis.

Sensitivity:
Same as vertical channel 1.

Accuracy:
Normal ±4%, X5 Gain ±6%.

Input Impedance:
Same as vertical channel 1.

Frequency Response:
DC to 2 MHz (-3 dB).

X-Y Phase Difference:
3^{o} or less at 50 kHz.

Maximum Input Voltage:
Same as vertical channel 1.

HORIZONTAL AMPLIFIER
(Input through EXT TRIG input)

EXT Horizontal Mode:
Trace swept by external horizontal signal. Vertical axis modes CH 1, CH 2, DUAL, and ADD.

Sensitivity:
Approximately 0.1 V/div.

Bandwidth:
DC to 2 MHz (-3 dB).

Phase Difference:
3° or less at 50 kHz.

Maximum Voltage:
100 V (dc + ac peak) to 1 kHz.

SWEEP SYSTEM

Sweep Speed:
0.2 µs/div to 0.5 s/div in 1-2-5 sequence, 20 steps. Vernier control provides fully adjustable sweep time between steps.

Accuracy:
±3%.

Sweep Magnification:
10X, ±5% (±8% for 0.2 µs/div and 0.5 µs/div).

Linearity (for eight center divisions of sweep):
Norm ±3%.
X10 MAG ±5% (±8% for 0.2 µs/div and 0.5 µs/div).

Holdoff:
Continuously adjustable from NORM to 2 times normal.

TRIGGERING

Trigger Modes:
AUTO (free run), NORM, FIX, X-Y, SINGLE.

Trigger Source:
CH 1, CH 2, ALT, LINE, EXT.

Trigger Coupling:

AC	10 Hz to 40 MHz.
DC	DC to 40 MHz.
HF REJ	10 Hz to 50 kHz.
TV	Line automatically selected at 50 µs/div and faster. Frame automatically selected at 0.1 ms/div and slower.

Trigger Sensitivity:

COUPLING	BANDWIDTH	INT	EXT
DC	DC - 10 MHz DC - 40 MHz	0.5 div 1.5 div	100 mV 200 mV
AC	Same as DC except increased attenuation below 10 Hz		
LF (HF REJ)	Same as AC except increased attenuation above 50 kHz.		
TV		2 div	200 mV
AUTO	Same as AC except lower limit is 50 Hz.		
FIX, ALT	Same as AC plus 0.5 div for signal of duty cycle 20:80 and repetition frequency of 50 Hz to 40 MHz.		

External Trigger:

Input Impedance:
1 MΩ ±2%, approximately 30 pF.

Maximum Input Voltage:
100 V (dc + ac peak) to 1 kHz.

OTHER SPECIFICATIONS

Calibrating Voltage:
1 kHz Positive Square Wave (±5%), 2 V p-p (±2%). Duty cycle of 50% ±2%.

Intensity Modulation:

Input Signal:
TTL level, intensity decreasing with more positive levels.

Input Impedance:
Approximately 5 kΩ.

Usable Frequency Range:
DC to 5 MHz.

Maximum Input Voltage:
100 V (dc + ac peak) to 1 kHz.

CH 1 Output (on rear panel):

Output Voltage:
50 mV/div (into 50-ohm load).

Output Impedance:
Approximately 50 ohms.

Frequency Response:
5 mV/ div to 5 V/div:
100 Hz to 40 MHz, -3 dB, into 50 Ω.
1 mV/div and 2 mV/div:
100 Hz to 15 MHz, -3 dB, into 50 Ω.

Trace Rotation:
Electrical, front panel adjustable.

Power Requirements:
100 V/120 V/220 V/230 V/240 V ±10%, 50/60 Hz, approximately 35 W.

Dimensions:
310 x 170 x 460 mm (13.4 x 5.7 x 15.0").

Weight:
7.1 kg (17.6 lb).

Operating Environment:
+10° to +35° C, 85% maximum relative humidity for full specifications.
0° to +40° C, 85% maximum relative humidity, full operating range.

SUPPLIED ACCESORIES:
Two 10:1/Direct Probes.
Instruction Manual.
Schematic Diagram and Parts List.

OPTIONAL ACCESSORIES:
10:1 Probe, PR-45.
100:1 Probe, PR-100.

CONTROLS AND INDICATORS

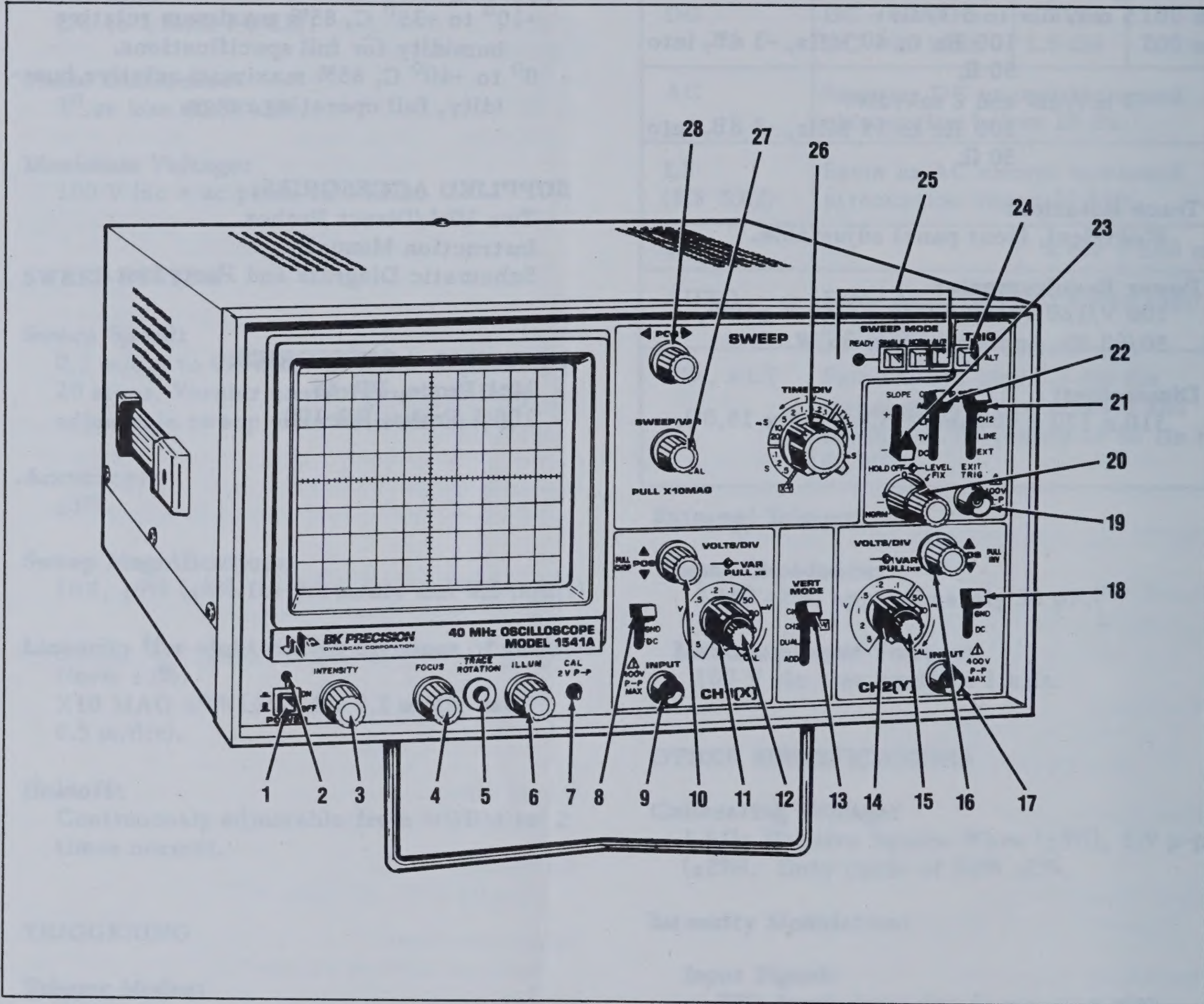

Fig. 1. Front Panel Controls And Indicators.

FRONT PANEL CONTROLS AND INDICATORS

CRT CONTROLS

1. **POWER Switch.** Turns oscilloscope power on and off.

2. **POWER Indicator.** Lights when oscilloscope is on.

3. **INTENSITY Control.** Adjusts brightness of trace.

4. **FOCUS Control.** Adjusts sharpness of trace.

5. **TRACE ROTATION Control.** Screwdriver adjustment used to adjust trace to optimum horizontal position.

6. **Scale ILLUMination Control.** Adjusts intensity of oscilloscope scale. When control is fully counterclockwise, oscillo-

scope scale illumination is off. Clockwise rotation of the control increases the illumination of the graticule scale.

7. **CAL 2 V p-p Terminal.** This terminal provides a 1 kHz, 2-volt peak-to-peak square wave signal. This is useful for probe compensation adjustment and a general check of oscilloscope calibration accuracy.

CHANNEL 1 CONTROLS

8. **AC-GND-DC Switch.** Three-position lever switch which operates as follows:
   AC:
   Channel 1 input signal is capacitively coupled; dc component is blocked.
   GND:
   Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.
   DC:
   Direct coupling of channel 1 input signal; both ac and dc component of signal produce vertical deflection.

9. **CH 1 (X) Jack.** Vertical input for channel 1. X axis input for X-Y operation.

10. **⬍ CH1 POSition, PULL CHOP Control.**
   ⬍ CH 1 POSition:
   Rotation adjusts vertical position of channel 1 trace.
   PULL CHOP (Push-Pull Switch):
   Selects chop method of dual-trace display. When this control is pulled out and dual-trace is selected, both waveforms will be displayed simultaneously, regardless of **TIME/DIV** or **ALT** control settings. When this control is pushed in and dual-trace is selected, the display method (chop or alternate) is automatically selected by the **TIME/DIV** control (unless overridden by the **ALT** switch).

11. **VOLTS/DIV Control.** Vertical attenuator for channel 1. Provides step adjustment of vertical sensitivity. When channel 1 **VAR** control is set to **CAL**, vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 sequence. In X-Y operation, this control provides step adjustment of X-axis sensitivity.

12. **VARiable, PULL X5 Control.**
   VARiable:
   Rotation provides vernier adjustment of channel 1 vertical gain. In the fully clockwise (**CAL**) position, the vertical attenuator is calibrated. In X-Y operation this control becomes the vernier X-axis gain control.
   PULL X5 (Push-Pull Switch):
   Multiplies channel 1 vertical gain five times; for example, 5 mV/div sensitivity becomes 1 mV/div.

13. **VERTical MODE Switch.**
   CH 1:
   Only the input signal to channel 1 is displayed on the CRT.
   CH 2/X-Y:
   Only the input signal to channel 2 is displayed on the CRT. Also, used in conjunction with **TIME/DIV** and trigger **SOURCE** switch to select **X-Y** operating mode.
   DUAL:
   The input signal to channel 1 and channel 2 are displayed simultaneously on two traces.
   ADD:
   The input from channel 1 and channel 2 are algebraically summed and displayed as a single signal. When the **CH 2 INV** function is activated, the input from channel 2 is subtracted from channel 1 and the difference is displayed as one signal.

CHANNEL 2 CONTROLS

14. **VOLTS/DIV Control.** Vertical attenuator for channel 2. Provides step adjustment of vertical sensitivity. When channel 2 **VAR** control is set to **CAL**, vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 se-

quence. In X-Y operation, provides step adjustment of Y-axis sensitivity.

15. **VARiable, PULL X5 Control.**

VARiable:

Rotation provides vernier adjustment of channel 2 vertical sensitivity. In the fully clockwise (**CAL**) position, the attenuator is calibrated. In X-Y operation this control becomes the vernier Y-axis gain control.

PULL X5 (Push-Pull Switch):

Multiplies channel 1 vertical gain five times; for example, 5 mV/div sensitivity becomes 1 mV/div.

16. **⇕ CH2 POSition, PULL INVert Control.**

⇕ CH2 POSition:

Rotation adjusts vertical position of channel 2 trace. In X-Y operation, rotation adjusts vertical position of display.

PULL INVert (Push-Pull Switch):

Selects inverse of normal polarity of channel 2 signal; inverted polarity when pulled out, normal polarity when pushed in.

17. **CH 2 (Y) Jack.** Vertical input for channel 2. Y-axis input in X-Y operation.

18. **AC-GND-DC Switch.** Three-position lever switch which operates as follows:

AC:

Channel 2 input signal is capacitively coupled; dc component is blocked.

GND:

Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.

DC:

Direct coupling of channel 2 input signal; both ac and dc component of signal produce vertical deflection.

TRIGGERING CONTROLS

19. **EXT TRIG Jack.** External trigger input for single and dual-trace operation. Also serves as sweep input for external horizontal operation.

20. **TRIGger LEVEL, HOLD OFF Control.**

TRIGger LEVEL:

Trigger level adjustment, determines point on the triggering waveform where the sweep is triggered. Rotation in the (-) direction selects a more negative point of triggering, and rotation in the (+) direction selects a more positive point of triggering. When the control is rotated fully counterclockwise (**FIX**), the **FIX** triggering mode is selected. In the **FIX** triggering mode, the trigger threshold is automatically set at the center of the waveform.

HOLD OFF:

Rotation of control adjusts holdoff time (trigger inhibit period beyond sweep duration). When control is rotated fully counterclockwise, holdoff is set to **NORM.** Holdoff period increases progressively with clockwise rotation to a maximum of about 2 times normal.

21. **TRIGger SOURCE Switch.** Selects source of sweep trigger. Four position lever switch with the following positions:

CH 1:

Channel 1 signal becomes sweep trigger for dual-trace operation (for single-trace operation, the channel displayed is the trigger signal unless the **LINE** or **EXT** position is selected).

CH 2:

Channel 2 signal becomes sweep trigger for dual-trace operation (for single trace operation, the channel displayed is the trigger signal unless the **LINE** or **EXT**, position is selected).

LINE:

Signal derived from the input line voltage (50/60 Hz) becomes trigger.

EXT:

Signal from **EXT TRIG** jack becomes sweep trigger.

22. **TRIGger COUPLING Switch.** Selects trigger coupling. Four-position lever switch with the following positions:

AC:
Trigger is capacitively coupled; dc component is blocked.

HF REJ:
Trigger is coupled through low pass filter. Frequencies above 40 kHz are attenuated.

TV:
Vertical or horizontal sync pulses are selected. When sweep speeds of 0.1 ms/div or slower are selected, vertical sync pulses are selected. When sweep speeds of 50 µs/div or faster are selected, horizontal sync pulses are selected.

23. **TRIGger SLOPE (-) Switch.** Two-position switch selects negative going or positive going trigger slope. When the switch is in (-) position, negative going (-) slope is selected and when the switch is in the (+) position, positive-going (+) slope is selected as the triggering point.

24. **ALT TRIG Switch.** Selects alternate trigger and alternate display mode when the switch is engaged and dual-trace display is selected. In the alternate trigger mode, the input signals alternate as the trigger source and triggering is impossible unless both input signals are of adequate level to trigger the sweep. In the alternate display mode when dual-trace display is selected, the waveforms will be displayed in an alternating fashion. However, if **PULL CHOP** control is in the pulled out position, **CHOP** display mode is selected (the **PULL CHOP** control overrides both the **TIME/DIV** and **ALT** setting) and the display cannot be synchronized since the chopping signal becomes the trigger source.

SWEEP CONTROLS

25. **SWEEP MODE Switches.** Three mechanically interactive switches used to select the desired triggering mode as follows:

AUTO:
Selects automatic triggering mode. Generates sweep (free runs) in absence of trigger; automatically reverts to triggered sweep operation when adequate trigger signal is present.

NORM:
Selects normal triggered sweep operation, which generates a sweep only when adequate trigger signal is present. When the oscilloscope is set up for multiple trigger sources (dual-trace display with **ALT** triggering selected), both channels must have adequate trigger signals to obtain a sweep.

SINGLE:
Selects single sweep operation. For dual-trace display, single sweep requires **CHOP** method of display; do not select **ALT**. A single sweep will begin when the next sync trigger occurs. After a single sweep, **SINGLE** must be pressed again to enable next single sweep. Indicator (**READY** LED) lights to show that single sweep operation is ready for triggering. Lights when **SINGLE** switch is operated and remains lit until one sweep is completed.

26. **TIME/DIV Control.** Provides step selection of sweep rate. When the sweep time **VAR** control is set to the **CAL** position, sweep rate is calibrated. Control has 20 steps from 0.2 µs/div to 0.5 s/div, in a 1-2-5 sequence. When control is rotated fully counterclockwise, X-Y/EXT HOR mode of operation is selected. If control is in **X-Y** position and trigger **SOURCE** switch is set to **CH 1/X-Y** position, oscilloscope is in X-Y operating mode. If control is in **X-Y** position and trigger **SOURCE** switch is set to **EXT** position, the signal connected to **EXT TRIG** jack controls sweep.

27. **SWEEP/VARiable, PULL X10 MAG Control.**

SWEEP/VARiable.:
Rotation of this control is the vernier adjustment for sweep rate. When the control is rotated fully clockwise (**CAL**), the sweep rate is calibrated.

PULL X10 MAG (Push-Pull Switch):
Selects ten times sweep magnification when pulled out (**X10 MAG**),

normal when pushed in. Expands sweep and increases maximum sweep rate to 20 ns/div.

28. **◄► POSition Control.** Horizontal position control. Adjusts horizontal position of display in all operating modes.

REAR PANEL CONTROLS

29. **GND Terminal.** Oscilloscope chassis ground and earth ground via 3-wire ac power cord.

30. **CH 1 OUT Jack.** Output terminal where sample of channel 1 signal is available. Amplitude is 50 millivolts per division of vertical deflection seen on CRT when terminated into 50 ohms. Output impedance is 50 ohms.

31. **Z AXIS INPUT Jack.** Input jack for intensity modulation of CRT electron beam. TTL compatible (5 volts p-p sensitivity). Positive signal levels decrease intensity.

32. **Fuse Holder.** Contains line fuse.

33. **Tilt Stand (not shown).**

34. **Feet/Cord Wrap.**

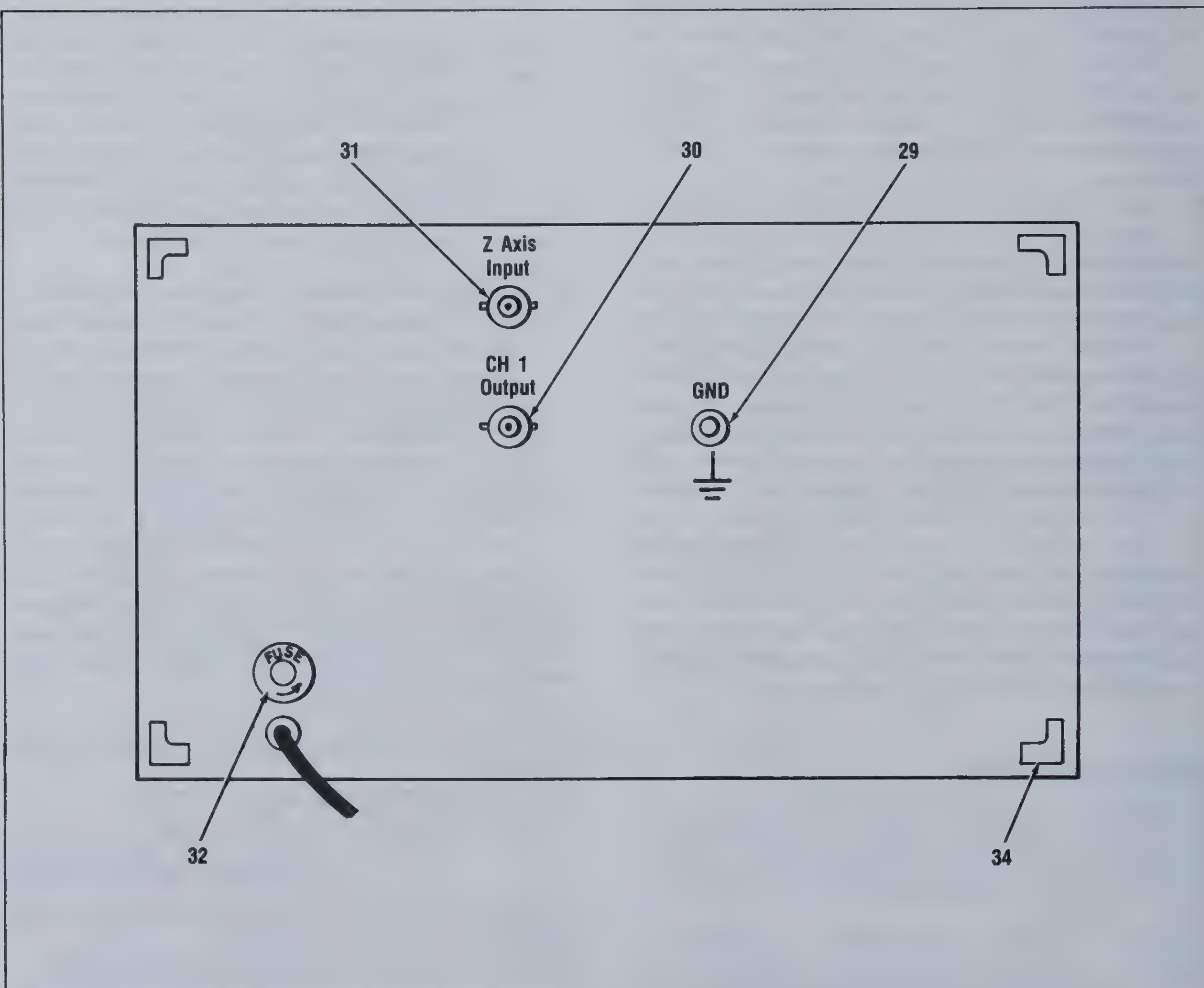

Fig. 2. Rear Panel Controls.

OPERATING INSTRUCTIONS

SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to help prevent electric shock.

1. *When the oscilloscope is used to make measurements in equipment that contains high voltage, there is always a certain amount of danger from electrical shock. The person using the oscilloscope in such conditions should be a qualified electronics technician or otherwise trained and qualified to work in such circumstances. Observe the TEST INSTRUMENT SAFETY recommendations listed on the inside front cover of this manual.*

2. *Do not operate this oscilloscope with the case removed unless you are a qualified service technician. High voltage up to 12,000 volts is present when the unit is operating with the case removed.*

3. *The ground wire of the 3-wire ac power plug places the chassis and housing of the oscilloscope at earth ground. Use only a 3-wire outlet, and do not attempt to defeat the ground wire connection or float the oscilloscope; to do so may pose a great safety hazard.*

4. *Special precautions are required to measure or observe line voltage waveforms with any oscilloscope. Use the following procedure:*

   a. *Do not connect the ground clip of the probe to either side of the line. The clip is already at earth ground and touching it to the hot side of the line may "weld" or "disintegrate" the probe tip and cause possible injury, plus possible damage to the scope or probe.*

   b. *Insert the probe tip into one side of the line voltage receptacle, then the other. One side of the receptacle should be "hot" and produce the waveform. The other side of the receptacle is the ac return and no waveform should result.*

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the oscilloscope.

1. Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. A spot will occur when the scope is set up for X-Y operation and no signal is applied. Either reduce the intensity so the spot is barely visible, apply signal, or switch back to normal sweep operation. It is also advisable to use low intensity with **AUTO** triggering and no signal applied for long periods. A high intensity trace at the same position could cause a line to become permanantly burned onto the screen.

2. Do not rest objects on top of the oscilloscope or otherwise obstruct the ventilating holes in the case, as this will increase the internal temperature.

3. Excessive voltage applied to the input jacks may damage the oscilloscope. The maximum ratings of the inputs are as follows:

   CH 1 and CH 2:
   400 V p-p; 400 V dc + ac peak.
   EXT TRIG:
   100 V dc + ac peak.
   Z AXIS INPUT:
   50 V dc + ac peak.

   Never apply external voltage to oscilloscope output jacks.

4. Always connect a cable from the ground terminal of the oscilloscope to the chassis of the equipment under test. Without this precaution, the entire current for the equipment under test may be drawn through the probe clip leads under certain circumstances. Such conditions could also pose a safety hazard, which the ground cable will prevent.

5. The probe ground clips are at oscilloscope ground and should be connected only to the common of the equipment under test. To measure with respect to any point other than the common, use CH 1 - CH 2 subtract operation (**ADD** mode and **CH 2 INV**), with the channel 1 probe to the point of measurement and the channel 2 probe to the point of reference. Use this method even if the reference point is a dc voltage with no signal.

OPERATING TIPS

The following recommendations will help obtain the best performance from the oscilloscope.

1. Always use the probe ground clips for best results, attached to a circuit ground point near the point of measurement. Do not rely solely on an external ground wire in lieu of the probe ground clips as undesired signals may be induced.

2. Avoid the following operating conditions:
   a. Direct sunlight.
   b. High temperature and humidity.
   c. Mechanical vibration.
   d. Electrical noise and strong magnetic fields, such as near large motors, power supplies, transformers, etc.

3. Occasionally check trace rotation, probe compensation, and calibration accuracy of the oscilloscope using the procedures found in the MAINTENANCE section of this manual.

4. Terminate the output of a signal generator into its characteristic impedance to minimize ringing, especially if the signal has fast edges such as square waves or pulses. For example, the typical 50 Ω output of a square wave generator should be terminated into an external 50 Ω terminating resistor and connected to the oscilloscope with 50 Ω coaxial cable.

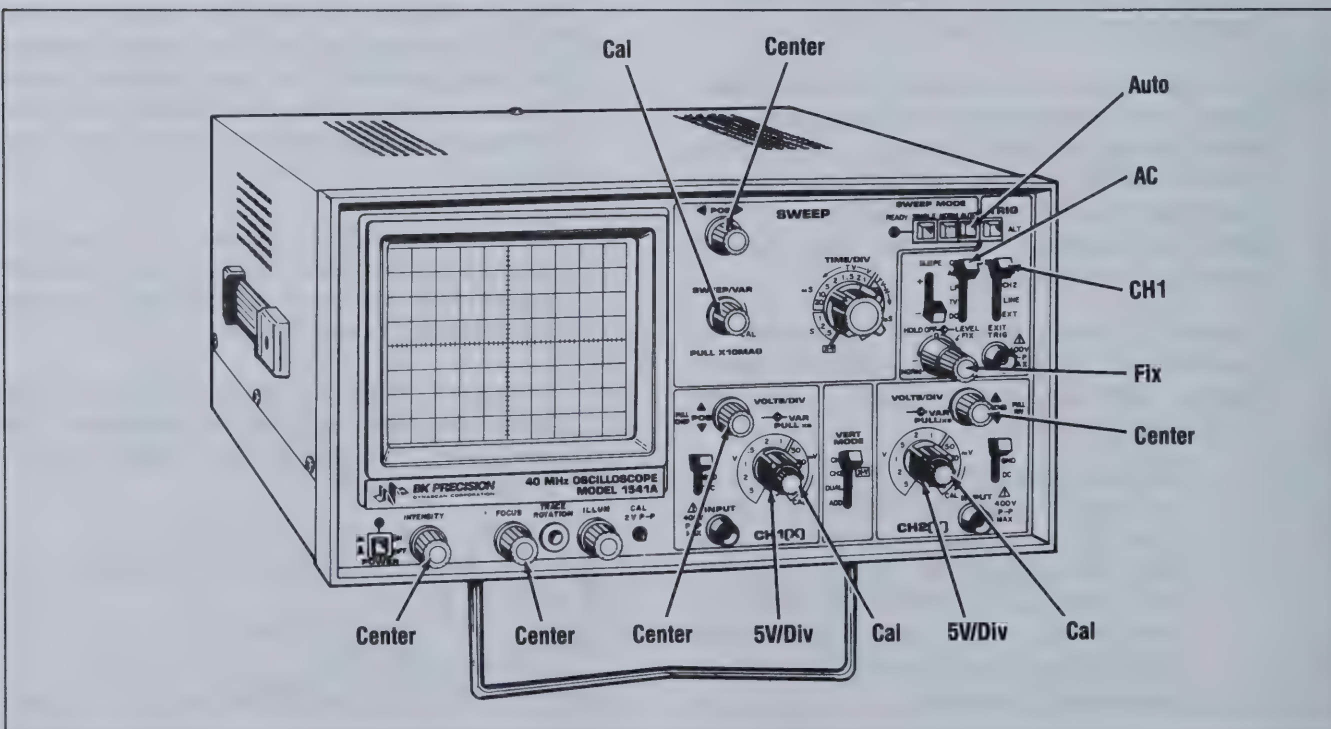

Fig. 3. Initial Control Settings.

5. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation should be adjusted initially, then the same probe always used with the same channel. Probe compensation should be readjusted when a probe from a different oscilloscope is used.

INITIAL STARTING PROCEDURE

Until you familiarize yourself with the use of all controls, the settings shown in Fig. 3 may be used as a reference point to obtain a trace on the CRT in preparation for waveform observation.

1. Engage the **POWER** switch; the unit will be turned on and the pilot light will be illuminated. Adjust scale illumination level with the **ILLUM** control. When the control is turned fully clockwise, the scale is illuminated at full brightness.

2. The controls should be set as follows; **VERT MODE** to **CH 1, SWEEP MODE** to **AUTO**, and **TRIG SOURCE** to **CH 1.**

3. A trace should appear on the CRT. Adjust the trace brightness with the **INTEN** control and the trace sharpness with the **FOCUS** control.

SINGLE TRACE DISPLAY

Either channel 1 or channel 2 may be used for single-trace operation. The advantage of using channel 2 is that the waveform on the display can be inverted if desired with the **PULL INV** switch.

1. Perform the steps of the "Initial Starting Procedure" with the **VERT MODE** switch set to **CH 2.**

2. Connect the probe to the **CH 2 (Y)** input jack.

3. Connect the probe ground clip to the chassis or common of the equipment under test. Connect the probe tip to the point of measurement.

4. If no waveforms appear, increase the sensitivity by turning the **CH 2 VOLTS/DIV** control clockwise to a position that gives 2 to 6 divisions vertical deflection.

5. The display on the CRT may be unsynchronized. Refer to the "Triggering" paragraphs in this section for procedures on setting triggering and sweep controls to obtain a stable display showing the desired number of waveforms.

DUAL TRACE DISPLAY

In observing simultaneous waveforms on channel 1 and 2, the waveforms are usually related in frequency, or one of the waveforms is synchronized to the other, although the basic frequencies are different. If the two waveforms have no phase or frequency relationship, there is seldom reason to observe both waveforms simultaneously. However, with **ALT** triggering, two waveforms not related in frequency or period can be simultaneously viewed.

1. Connect probes to both **CH 1 (X)** and **CH 2 (Y)** input jacks.

2. Connect the ground clips of the probes to the chassis or common of the equipment under test. Connect the tips of the probes to the two points in the circuit where waveforms are to be measured.

3. With the **ADD** function selected, the algebraic sum of CH 1 + CH 2 is displayed as a single trace. When the **PULL INV** button is also engaged, the algebraic difference of CH 1 - CH 2 is displayed.

4. To view both waveforms simultaneously, set the **VERT MODE** switch to **DUAL.**

5. When sweep times of 0.5 ms/div and faster are selected, the **ALT** display mode is automatically selected. When sweep times slower than 0.5 ms/div are selected, the **CHOP** display mode is automatically selected. It is possible to override the automatic selection by pulling out the **PULL CHOP** switch to select the **CHOP** display mode at all

sweep speeds or by pressing the **ALT TRIG** switch to select **ALT** display mode at all sweep speeds. However, do not engage **ALT** and **CHOP** display at the same time. Because selecting the **ALT** display mode also selects the **ALT TRIG** mode, selecting both **ALT** and **CHOP** simultaneously results in a display that cannot be synchronized since the chop signal itself becomes the trigger source. Use the **ALT** mode only, or select a trigger source of channel 1 or channel 2.

a. In the **ALT** mode, one sweep displays the channel 1 signal and the next sweep displays the channel 2 signal in an alternating sequence. Alternate sweep is normally used for viewing high-frequency or high-speed waveforms at sweep times of 1 ms/div and faster, but may be selected at any sweep time.

b. In the **CHOP** mode, the sweep is chopped at an approximate 250 kHz rate and switched between channel 1 and channel 2. Chop sweep is normally used for low-frequency or low-speed waveforms at sweep times of 1 ms/div and slower. If chop sweep is used at sweep times of 0.2 ms/div and faster, the chop rate becomes a significant portion of the sweep and may become visible in the displayed waveform. However, you may select chop sweep at any sweep time for special applications. For example, the only way to observe simultaneous events on a dual-trace scope at any sweep rate is with chop sweep.

6. Adjust the **CH 1** and **CH 2 POS** controls to place the channel 1 trace above the channel 2 trace.

7. Set the **CH 1** and **CH 2 VOLTS/DIV** controls to a position that gives 2 to 3 divisions of vertical deflection for each trace. If the display on the screen is unsynchronized, refer to the "Triggering" paragraphs in this section of the manual for procedures for setting triggering and sweep time controls to obtain a stable display showing the desired number of waveforms.

TRIGGERING

The Model 1541A Oscilloscope provides versatility in sync triggering for ability to obtain a stable, jitter-free display in single-trace, or dual-trace operation. The proper settings depend upon the type of waveforms being observed and the type of measurement desired. An explanation of the various controls which affect synchronization is given to help you select the proper setting over a wide range of conditions.

SWEEP MODE Switches

1. The **NORM** switch provides normal triggered sweep operation. The sweep remains at rest until the selected trigger source signal crosses the threshold level set by the **TRIG LEVEL** control. The trigger causes one sweep to be generated, after which the sweep again remains at rest until triggered. In the **NORM** position, there will be no trace unless an adequate trigger signal is present. In the **ALT** mode of dual trace operation with **NORM** sweep selected, there will be no trace unless both channel 1 and channel 2 signals are adequate for triggering. Typically, signals that produce even 1/2 division of vertical deflection are adequate for normal triggered sweep operation.

2. When the **AUTO** switch is engaged, automatic sweep operation is selected. In automatic sweep operation, the sweep generator free runs to generate a sweep without a trigger signal. However, it automatically switches to triggered sweep operation if an acceptable trigger source signal is present. The **AUTO** position is handy when first setting up the scope to observe a waveform; it provides sweep for waveform observation until other controls can be properly set. Once the controls are set, operation is often switched back to the **NORM** triggering

mode, since it is more sensitive. Automatic sweep must be used for dc measurements and signals of such low amplitude that they will not trigger the sweep.

NOTE

In the **X-Y** mode, the sweep generator and triggering circuits are disconnected and have no effect.

TRIGger SOURCE Switch

The **TRIG SOURCE** switch **CH 1, CH 2,** etc.) selects the signal to be used as the sync trigger. In the single trace display mode (**VERT MODE** set to either **CH 1** or **CH 2**), the channel selected for display is automatically selected as the trigger source unless the **TRIG SOURCE** switch is set to the **LINE** or **EXT** position.

1. If the **TRIG SOURCE** switch is set to **CH 1** (or **CH 2**) the channel 1 (or channel 2) signal becomes the trigger source when **DUAL** or **ADD VERT MODE** is selected. **CH 1,** or **CH 2** is often used as the trigger source for phase or timing comparison measurements.

2. If the **TRIG SOURCE** switch is set to the **LINE** position, triggering is derived from the input line voltage (50/60 Hz). This is useful for measurements that are related to line frequency.

3. If the **TRIG SOURCE** switch is set to the **EXT** position, the signal applied to the **EXT TRIG** jack becomes the trigger source. This signal must have a timing relationship to the displayed waveform(s) for a synchronized display.

ALT TRIG Switch

The **ALT TRIG** switch is used to select alternate triggering and alternate display when the **DUAL**-trace **VERT MODE** is selected (the switch has no effect in the **CH 1, CH 2,** or **ADD** modes). In the alternate triggering mode (when dual-trace operation is selected), the trigger source alternates between channel 1 and channel 2 with each sweep. This is convenient for checking amplitudes, waveshape, or waveform period measurements, and even permits simultaneous observation of two waveforms which are not related in frequency or period. However, this setting is not suitable for phase or timing comparison measurements. For such measurements, both traces must be triggered by the same sync signal.

When the **PULL CHOP** and the **ALT TRIG** switches are both engaged during dual-trace operation, synchronization of the display is not possible because the chopping signal becomes the trigger. Use the **ALT** mode by itself, or select **CH 1** or **CH 2** as the trigger source.

TRIG LEVEL and SLOPE Controls
(Refer to Fig. 4)

A sweep trigger is developed when the trigger source signal crosses a preset threshold level. Rotation of the **TRIG LEVEL** control varies the threshold level. In the + direction, the triggering threshold shifts to a more positive value, and in the - direction, the triggering threshold shifts to a more negative value. When the control is centered, the threshold level is set at the approximate average of the signal used as the triggering source. Rotating the control fully counterclockwise past the click stop, selects the **FIX** trigger mode. In the **FIX** mode, the trigger point is automatically set at the center of the waveform. Proper adjustment of this control usually synchronizes the display.

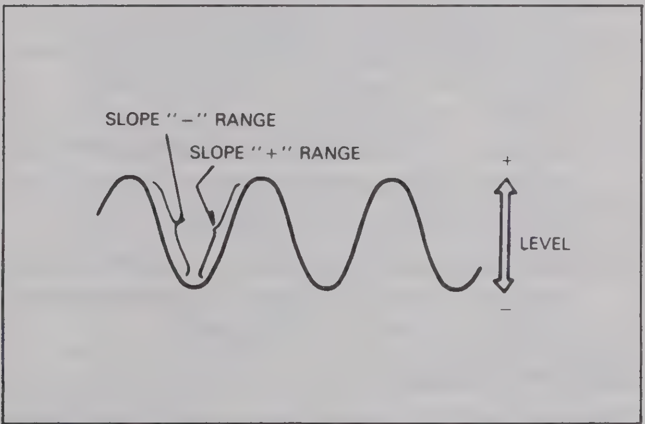

Fig. 4. Function of Slope and Level Controls.

The **TRIG LEVEL** control adjusts the start of the sweep to almost any desired point on a waveform. On sine wave signals, the phase at which sweep begins is variable. Note that if the **TRIG LEVEL** control is rotated toward its extreme + or – setting, no sweep will be developed in the **NORM** trigger mode because the

triggering threshold exceeds the peak amplitude of the sync signal.

When the **TRIG SLOPE** control is set to the (+) position (up), the sweep is developed from the trigger source waveform as it crosses the threshold level in a positive-going direction. When the **TRIG SLOPE** control is set to the (–) position (down), a sweep trigger is developed from the trigger source waveform as it crosses the threshold level in a negative-going direction.

COUPLING Switch

1. Use the **AC** position for viewing most types of waveforms. The trigger signal is capacitively coupled and may be used for all signals from 10 Hz to 40 MHz.
2. Use the **LF** position to eliminate high frequency components for stable triggering of low frequency signals.
3. The **TV** position is primarily for viewing composite video waveforms. A sync separator circuit separates sync pulses from video. Vertical sync pulses are selected as trigger when sweep speeds of 0.1 ms/div and slower are selected (**TV V**) and horizontal sync pulses are selected as trigger when sweep speeds of 50 µs/div and faster are selected (**TV H**). The **SLOPE** switch should be set according to the type of video signal (i.e., if the video signal has negative sync pulses, the **SLOPE** switch should be set to the (–) position. Additional procedures for observing video waveforms are given later in this section of the manual.
4. The **DC** position should be used when it is desirable to include the triggering effects of the dc component.

TIME/DIV Control

Set the **TIME/DIV** control to display the desired number of cycles of the waveform. If there are too many cycles displayed for good resolution, switch to a faster sweep speed. If only a line is displayed, try a slower sweep speed. When the sweep speed is faster than the waveform being observed, only part of it will be displayed, which may appear as a straight line for a square wave or pulse waveform.

HOLDOFF Control
(Refer to Fig. 5)

A "holdoff" period occurs immediately after the completion of each sweep, and is a period during which triggering of the next sweep is inhibited. The normal holdoff period varies with the sweep rate, but is adequate to assure complete retrace and stablization before the next sweep trigger is permitted. The **HOLDOFF** control allows this period to be extended by a variable amount if desired.

This control is usually set to the **NORM** position (fully counterclockwise) because no additional holdoff period is necessary. The **HOLDOFF** control is useful when a complex series of pulses appear periodically, such as in Fig. 5A. Improper sync may produce a double image as in Fig. 5B. Such a display could be synchronized with the **SWEEP/VAR** control, but this is impractical because time measurements are then uncalibrated. An alternate method of synchronizing the display is with the **HOLDOFF** control. The sweep speed remains the same, but the triggering of the next sweep is "held off" by the duration selected by the **HOLDOFF** control. Turn the **HOLDOFF** control clockwise from the **NORM** position until the sweep starts at the same point of the waveform each time. Maximum setting (turned fully clockwise) is 2 times greater than at the **NORM** setting.

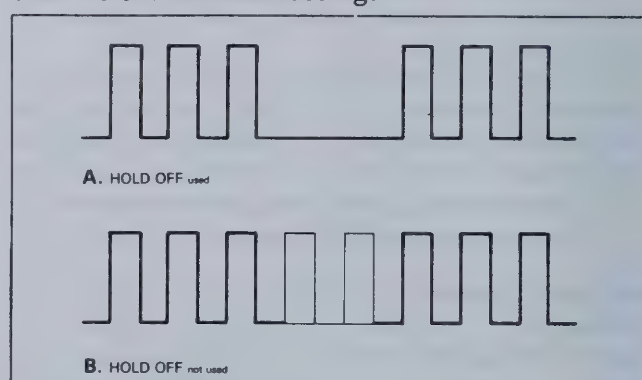

Fig. 5. Use of HOLDOFF control.

SINGLE SWEEP

This mode of display is useful for looking at non-synchronous or one time events.

1. Select either the **AUTO** or **NORM SWEEP MODE**. Apply a signal of approx-

imately the same amplitude and frequency as the signal that is to be observed as the trigger signal and set the trigger level.

2. Press and release the **SINGLE SWEEP MODE** switch (it will return to the disengaged position), make sure that the **READY** LED lights to indicate the reset condition. This LED goes out when the sweep period is completed.

3. The scope is now ready to operate in the **SINGLE** sweep mode of operation. Input of the trigger signal results in one and only one sweep.

NOTE

For dual-trace operation simultaneous observation is not possible using the **ALT** mode. Set the unit to the **CHOP** mode in this case.

X-Y OPERATION

X-Y operation permits the oscilloscope to perform many measurements not possible with conventional sweep operation. The CRT display becomes an electronic graph of two instantaneous voltages. The display may be a direct comparison of the two voltages such as a vectorscope display of video color bar patterns. However, the **X-Y** mode can be used to graph almost any dynamic characteristic if a transducer is used to change the characteristic (frequency, temperature, velocity, etc.) into a voltage. One common application is frequency response measurements, where the Y axis corresponds to signal amplitude and the X axis corresponds to frequency.

1. Set the **TRIG SOURCE** switch to the **CH 1/X-Y** position, the **VERT MODE** switch to the **CH 2/X-Y** position, and the **TIME/DIV** control to the **X-Y** position (fully counterclockwise). In this mode, channel 1 becomes the X axis input and channel 2 becomes the Y axis input.

2. The X and Y positions are now adjusted using the horizontal ◂▸ **POS** and **CH 2** ▴▾ **POS** controls respectively.

3. Adjust the amount of vertical (Y axis) deflection with the **CH 2 VOLTS/DIV** and **VAR** controls.

4. Adjust the amount of horizontal (X axis) deflection with the **CH 1 VOLTS/DIV** and **VAR** controls.

EXTERNAL HORIZONTAL OPERATION

In the **EXT** Horizontal operating mode, an external signal can be connected to the **EXT TRIG** input to control the oscilloscope sweep.

1. Set the **TRIG SOURCE** switch to the **EXT** position, the **VERT MODE** switch to the desired position (the **EXT** Horizontal mode can be used in single-trace, dual-trace, or add mode), and the **TIME/DIV** control to the **X-Y** position (fully counterclockwise). In this mode, the **EXT TRIG** input becomes the sweep signal.

2. The X and Y positions are now adjusted using the horizontal ◂▸ **POS** and ▴▾**POS** controls respectively.

3. Adjust the amount of vertical (Y axis) deflection with the appropriate **VOLTS/DIV** and **VAR** controls (**CH 1** for **CH 1 VERT MODE, CH 2** for **CH 2 VERT MODE,** or both **CH 1** and **CH 2** for **DUAL VERT MODE**).

4. The amount of horizontal (X axis) deflection is controlled by the amplitude of the signal applied to the **EXT TRIG** jack.

VIDEO SIGNAL OBSERVATION

Setting the **TRIG COUPLING** switch to the **TV** position permits selection of vertical or horizontal sync pulses for sweep triggering when viewing composite video waveforms.

The **TV V** mode is automatically selected at sweep rates of 0.1 ms/div and slower. Vertical sync pulses are selected as trigger to permit viewing of vertical fields and frames of video. A sweep time of 2 ms/div is appropriate for viewing fields of video and 5 ms/div for complete frames (two interlaced fields) of video.

The **TV H** mode is automatically selected at sweep rates of 50 µs/div and slower. Horizontal sync pulses are selected as trigger to permit viewing of horizontal lines of video. A sweep time of about 10 µs/div is appropriate

for displaying lines of video. The **SWEEP/VAR** control can be set to display the exact number of waveforms desired.

At most points of measurement, a composite video signal is of the (-) polarity, that is, the sync pulses are negative and the video is positive. In this case, use **(-) SLOPE.** If the waveform is taken at a circuit point where the video waveform is inverted, the sync pulses are positive and the video is negative. In this case, use **(+) SLOPE.**

DC VOLTAGE MEASUREMENTS
(Refer to Fig. 6)

The following technique may be used to measure the instantaneous dc level at any portion of a waveform, or to measure a dc voltage where no waveform is present.

1. Connect the signal to be measured to the input jack and set the **VERT MODE** switch to the channel to be used. Set the **VOLTS/DIV** and **TIME/DIV** controls to obtain a normal display of the waveform to be measured. The **SWEEP/VAR** and volts/div **VAR** controls must be set to **CAL.**

2. Press the **AUTO SWEEP MODE** switch and set the **AC-GND-DC** switch to **GND**, which establishes a trace at the zero volt reference. Using the ⬍ **POS** control, adjust the trace to the desired reference level position, making sure not to disturb this setting once made.

3. Set the **AC-GND-DC** switch to **DC** to observe the waveform, including its dc component. If an inappropriate reference level position was selected in step 2 or an inappropriate **VOLTS/DIV** setting was made, the waveform may not be visible at this point (deflected completely off the screen). This is especially true when the dc component is large with respect to the waveform amplitude. If so, reset the **VOLTS/DIV** control and repeat steps 2 and 3 until the waveform and the zero reference are both on the screen.

4. Use the ◂▸ **POS** control to bring the portion of the waveform to be measured to the center vertical graduation line of the graticule scale.

5. Measure the vertical distance from the zero reference level to the point to be measured (at least 3 divisions desirable for best accuracy). The reference level can be rechecked by momentarily returning the **AC-GND-DC** switch to **GND**.

6. Multiply the distance measured above by the **VOLTS/DIV** setting and the probe attenuation ratio as well. Voltages above the reference level are positive and voltages below the reference level are negative.

The measurement is summarized by the following equation:

DC level = Vert div x **VOLTS/DIV** x Probe

For the example shown in Fig. 6, the point being measured is 3.8 divisions from the reference level (ground potential). If the **VOLTS/DIV** control is set to 0.2 V and a 10:1 probe is used, the dc voltage level is calculated as follows:

$$\text{DC level} = 3.8\ (\text{div}) \times 0.2\ (\text{V/div}) \times 10$$
$$= 7.6\ \text{V}$$

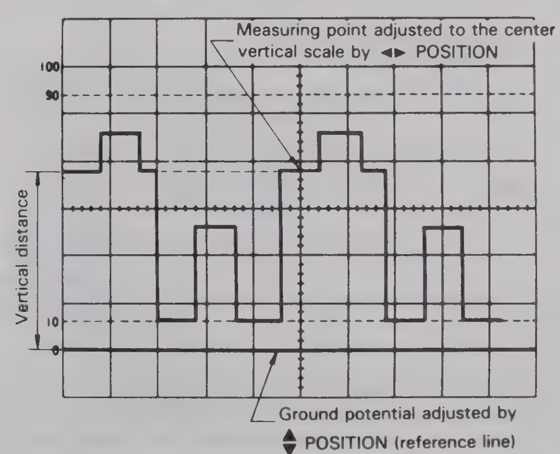

Fig. 6. DC Voltage Measurement.

MEASUREMENTS OF VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM
(Refer to Fig. 7)

This procedure may be used to measure peak-to-peak voltages, or for measuring the

voltage difference between any two points on a waveform.

1. Connect the signal to be measured to the input connector, set the **VERT MODE** switch to the channel to be used, and set the **AC-GND-DC** switch to **AC**. Set the **VOLTS/DIV** and **TIME/DIV** controls to obtain a normal display of the waveform to be measured. The volts/div **VAR** control must be set to **CAL.**

2. Using the ▲▼ **POS** control, adjust the waveform position such that one of the two points falls on a major horizontal graduation line.

3. Using the ◄► **POS** control, adjust the second point to coincide with the center vertical graduation line.

4. Measure the vertical distance between the two points (at least 3 divisions desirable for best accuracy). Multiply the number of divisions by the setting of the **VOLTS/DIV** control. If a probe is used, further multiply this by the probe attenuation ratio.

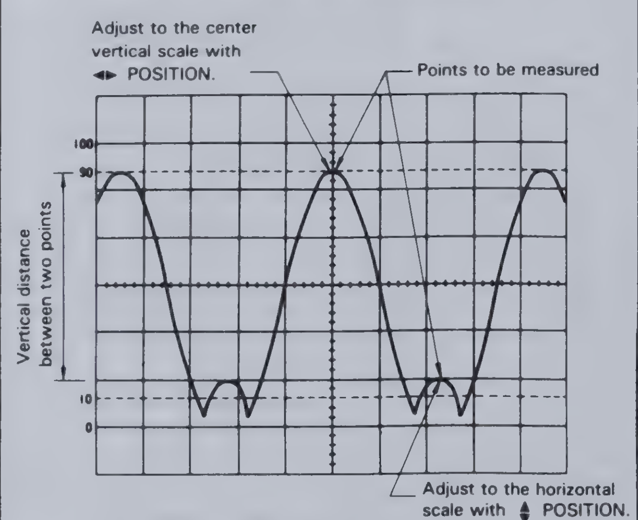

Fig. 7. Voltage Measurement.

The measurement is summarized by the following equation:

Voltage = Vert div x **VOLTS/DIV** x probe

For the example shown in Fig. 7, the two points are separated by 4.4 divisions vertically. If the **VOLTS/DIV** setting is 20 mV and a 10:1 probe is used, the voltage is calculated as follows:

$$\text{Voltage} = 4.4\ (\text{div}) \times 20\ (\text{mV/div}) \times 10$$

$$= 880\ \text{mV}$$

ADD MODE APPLICATIONS

Differential Measurements
(Refer to Figs. 8 and 9)

The **ADD** mode can be conveniently used to measure a signal with a reference point other than earth ground. For example, if you wanted to measure the signal present across R2 in Fig. 8, you would use the following technique:

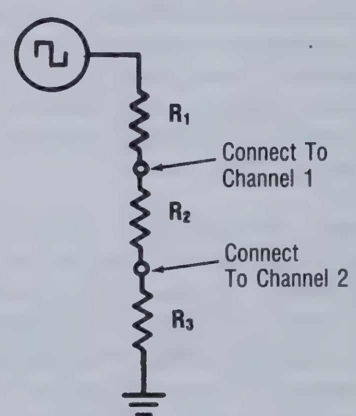

Fig. 8. Voltage Measurement with Reference Other than Earth Ground.

1. Connect channel 2 to the desired reference point and connect channel 1 to the desired point of measurement.

2. Select the subtract mode of operation by setting the **VERT MODE** switch to the **ADD** position and pulling out the **PULL/INV** switch.

3. Adjust the **CH 1** and **CH 2 VOLTS/DIV** and **TIME/DIV** controls to obtain a normal display of the waveform to be measured. The **VAR** controls must both be set

to **CAL** to make voltage measurements. Also, make sure that both attenuator controls are set to the same **VOLTS/DIV** settings.

4. Using the ch 1 or ch 2 ▲▼ **POSition** control, adjust the waveform position such that one of two points fall on a major horizontal graduation line.

5. Using the ◀▶ **POSition**, adjust the second point to coincide with the center vertical graduation line.

6. Measure the vertical distance between the two points (at least 3 divisions desirable for best accuracy). Multiply the number of divisions by the setting of either **VOLTS/DIV** control. If probes are used, further multiply this by the attenuation ratio of either probe (make sure that both probes are of the same attenuation ratio).

The measurement is summarized by the following equation:

Voltage = Vert div x **VOLTS/DIV** x probe

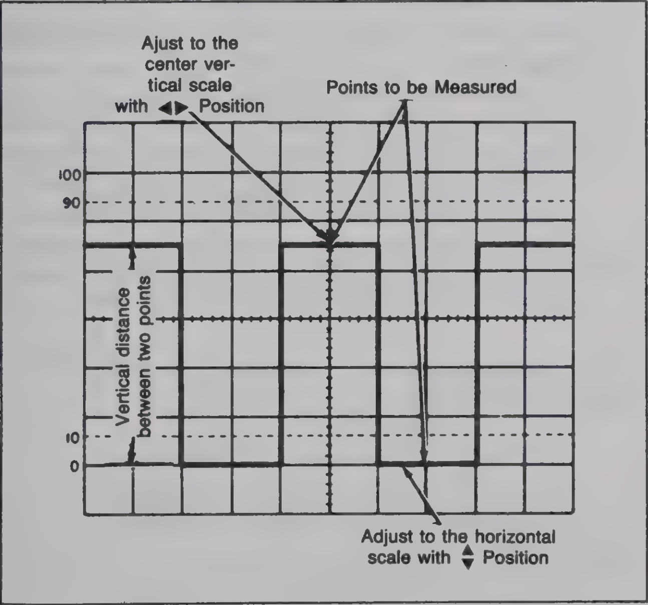

Fig. 9. Differential Voltage Measurement.

For the example shown in Fig. 9, the two points are separated by 4.5 divisions vertically. If the **VOLTS/DIV** setting is 0.1 V and a 10:1 probe is used, the voltage is calculated as follows:

Voltage = 4.5 (div) x 0.1 (V/div) x 10

= 4.5 V

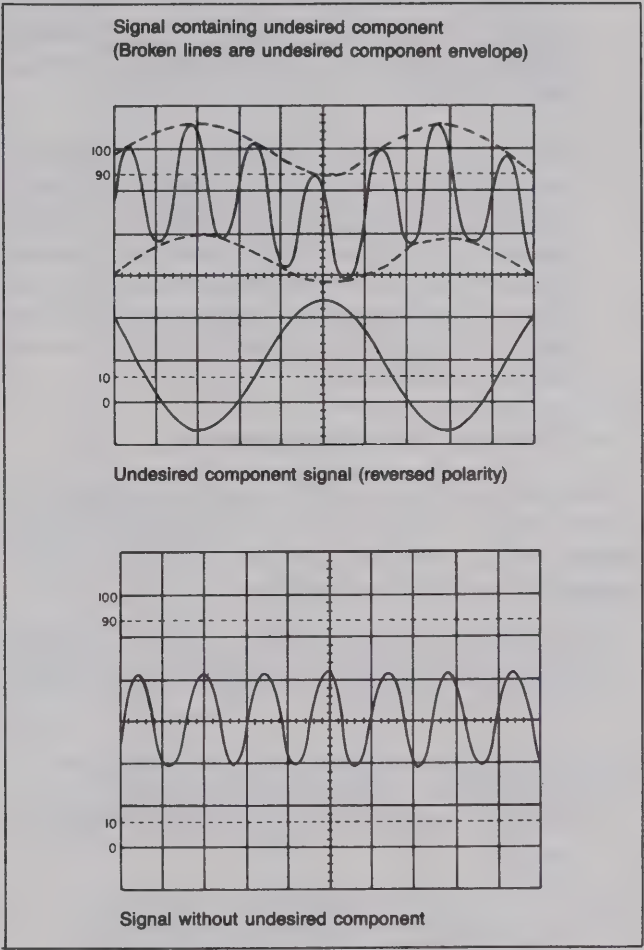

Fig. 10. Eliminating An Undesired Signal Component.

Elimination of an Undesired Signal Component
(Refer to Fig. 10)

Another application of the **ADD** mode is to cancel out the effect of an undesired signal component which is superimposed on the signal you wish to observe (for example, undesired 60 Hz hum superimposed on an rf signal).

1. Apply the signal containing an undesired component to the **CH 1 (X)** input jack and the undesired signal itself alone to the **CH 2 (Y)** input jack.

2. Select the **DUAL**-trace mode, pull out the **PULL CHOP** switch, and set the

TRIG SOURCE switch to **CH 2.** Adjust the controls to display two signals, such as shown in Fig. 10. Verify that the channel 2 trace represents the unwanted signal in reverse polarity. The polarity may be reversed by engaging the **PULL INV** switch.

3. Now set the **VERT MODE** switch to **ADD** and push in the **PULL CHOP** control. Adjust the **CH 2 VOLTS/DIV** and **VAR** controls so that the undesired signal component is cancelled as much as possible. The remaining signal should be the signal you wish to observe alone, free of the unwanted signal.

Push-Pull Amplifier Measurements

The oscilloscope's **ADD** mode can also be conveniently used to make signal measurements and check for proper balance at the outputs of push-pull amplifiers.

1. Connect one channel to one amplifier output and the other channel to the other amplifier output.
2. Select the subtract mode of operation by setting the **VERT MODE** switch to the **ADD** position and pulling the **PULL INV** switch.

NOTE
Because the two outputs of a push-pull amplifier are out of phase they tend to subtract. It is necessary to invert the channel 2 input to cause the signals to add.

3. Adjust the **CH 1** and **CH 2 VOLTS/DIV** and **TIME/DIV** controls to obtain a normal display of the waveform to be measured. The **VAR** controls must both be set to **CAL** to make voltage measurements. Also, make sure that both attenuator controls are set to the same **VOLTS/DIV** settings.
4. Make peak-to-peak signal measurements by performing steps 4 through 6 of "Differential Voltage Measurements".
5. To check amplifier balance, press the **PULL INV** switch and observe the display. If the amplifier is perfectly balanced, the two outputs should fully cancel each other. The resulting displayed waveform should be a flat trace. Any displayed signal equals the imbalance.

TIME MEASUREMENTS
(Refer to Fig. 11)

This is the procedure for making time (period) measurements between two points on a waveform. The two points may be the beginning and ending of one complete cycle if desired.

1. Connect the signal to be measured to the input connector and set the **VERT MODE** switch to the channel to be used. Set the **VOLTS/DIV** and **TIME/DIV** controls to obtain a normal display of the waveform to be measured. Be sure the **SWEEP/VAR** control is set to **CAL.**
2. Using the ⬍ **POS** control, set one of the points to be used as a reference to coincide with the horizontal center line. Use the ◂▸ **POS** control to set this point at the intersection of any vertical graduation line.
3. Measure the horizontal distance between the two points (at least 4 divisions desirable for best accuracy). Multiply this by the setting of the **TIME/DIV** control to obtain the time between the two points. If **X10 MAG** is used, multiply this further by 1/10.

The measurement is summarized by the following equation:

Time = Hor div x **TIME/DIV**

(x 1/10 if **X10 MAG** is used)

For the example shown in Fig. 11, the horizontal distance between the two points is 5.4 divisions. If the **TIME/DIV** setting is 0.2 ms and **X10 MAG** is not used, the time period is calculated as follows:

Time = 5.4 (div) x 0.2 (ms/div)

= 1.08 ms

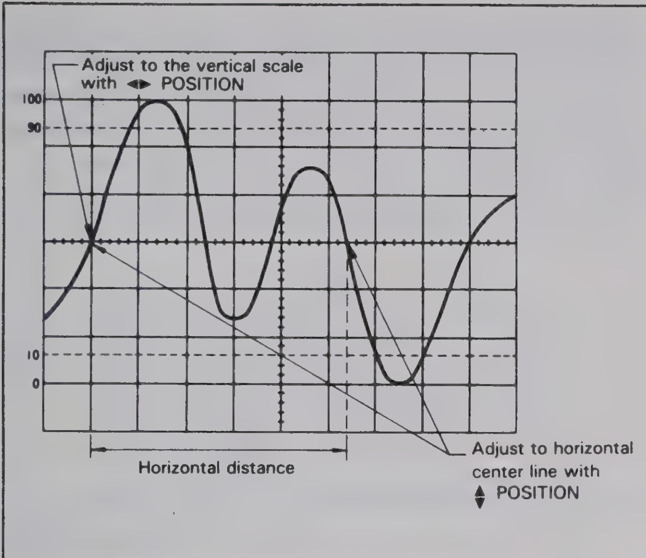

Fig. 11. Time Measurement.

FREQUENCY MEASUREMENTS

Method No. 1
(Refer to Fig. 12)

Frequency measurements are made by measuring the time period of one cycle of waveform and calculating the frequency, which equals the reciprocal of the time period.

1. Set up the oscilloscope to display one cycle of waveform (see Fig. 12).

2. Measure the time period of one cycle and calculate the frequency as follows:

$$\text{Freq} = \frac{1}{\text{Period}}$$

In the example shown in Fig. 12, a period of 40 µs is observed. Substituting this value into the above equation, the frequency is calculated as follows:

$$\text{Freq} = \frac{1}{40 \times 10^{-6}}$$

$$= 2.5 \times 10^{4}$$

$$= 25 \text{ kHz}$$

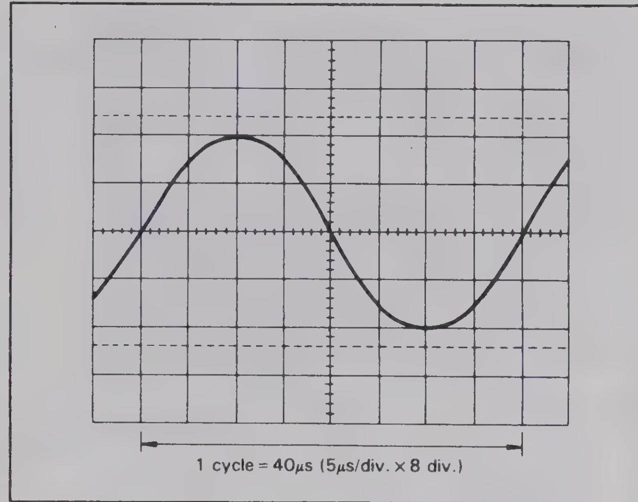

Fig. 12. Frequency Measurement.

Method No. 2
(Refer to Fig. 13)

While the previously described method relies upon direct period measurement of one cycle, the frequency may also be measured by counting the number of cycles present in a given time period.

1. Set up the oscilloscope to display several cycles of the waveform. The **SWEEP/VAR** control must be set to **CAL.**

2. Count the number of cycles of waveform between a chosen set of vertical graduation lines (see Fig. 13).

3. Multiply the number of horizontal divisions by the **TIME/DIV** setting to calculate the time span. Multiply the reciprocal of this value by the number of cycles present in the time span. If **X10 MAG** is used, multiply this further by 10. Note that errors will occur for displays having only a few cycles.

The measurement is summarized by the following equation:

$$\text{Freq} = \frac{\text{No of cycles (x 10 for X10 MAG)}}{\text{Hor div} \times \textbf{TIME/DIV}}$$

For the example shown in Fig. 13, there are 10 cycles within 7 divisions. If the **TIME/DIV** setting is 5 µs and **X10 MAG** is not used, the frequency is calculated as follows:

$$\text{Freq} = \frac{10\ \text{(cycles)}}{7\ \text{(div)} \times 5\ (\mu s)} = 285.7\ \text{kHz}$$

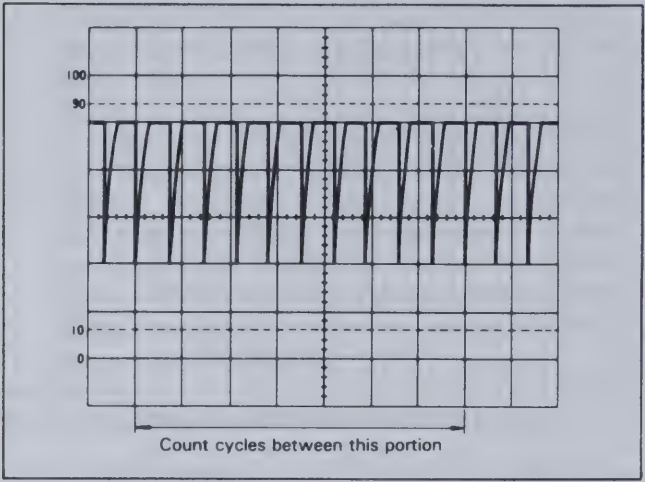

Fig. 13. Alternate Method of Frequency Measurement.

PULSE WIDTH MEASUREMENTS

(Refer to Fig. 14)

1. Apply the pulse signal to the input jack and set the **VERT MODE** switch to the channel to be used.

2. Use the **VOLTS/DIV** and volts/div **VAR** controls to adjust the display so the waveform is easily observed. Use the ⬍ **POS** control to position the pulse over the center horizontal graduation line. Use the ◂▸ **POS** control to align the leading edge of the pulse with one of the vertical graduation lines.

3. Measure the distance between the leading edge and trailing edge of the pulse (along the center horizontal graduation line). Be sure that the **SWEEP/VAR** control is set to **CAL.** Multiply the number of horizontal divisions by the **TIME/DIV**, and if **X10 MAG** is used, further multiply this value by 1/10.

The measurement is summarized by the following equation:

Pulse Width = Hor div x **TIME/DIV**

(x 1/10 if **X10 MAG** is used)

For the example shown in Fig. 14, the pulse width at the center of the pulse is 4.6 divisions. If the **TIME/DIV** setting is 0.2 ms and **X10 MAG** is used, the pulse width is calculated as follows:

Pulse Width =

$$4.6\ \text{(div)} \times 0.2\ \text{(ms/div)} \times 1/10$$

$$= .092\ \text{ms or } 92\ \mu s$$

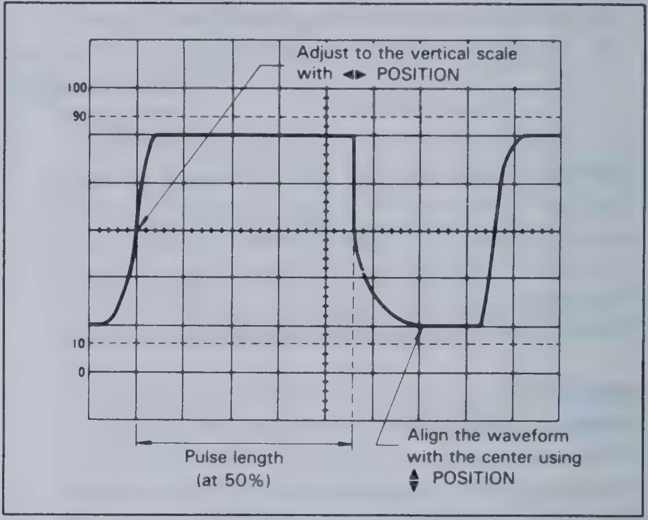

Fig. 14. Pulse Width Measurement.

PULSE RISE TIME AND FALL TIME MEASUREMENTS

Method No. 1:
(Refer to Fig. 15)

For rise time and fall time measurements, the 10% and 90% amplitude points are used as starting and ending reference points.

1. Apply a signal to the input jack and set the **VERT MODE** switch to the channel to be used. Use the **VOLTS/DIV** and volts/div **VAR** controls to adjust the waveform peak to peak height to six divisions.

2. Using the ⬍ **POS** control, adjust the display so that the waveform is centered vertically on the display. Set the **TIME/DIV** control to a setting as fast as possible while still being able to observe the 10% and 90% points. Set the **SWEEP/VAR** control to the **CAL** position.

3. Use the ◄► **POS** control to adjust the 10% point to coincide with a vertical graduation line and measure the horizontal distance in divisions between the 10% and 90% points on the waveform. Multiply this by the **TIME/DIV** setting and also by 1/10 if the **X10 MAG** mode was used.

NOTE
Be sure that the correct 10% and 90% lines are used. For such measurements the 0, 10, 90, and 100% points are marked on the CRT screen.

The measurement is summarized by the following equation:

Rise Time = Hor div x **TIME/DIV**

(x 1/10 if X10 MAG is used)

For the example shown in Fig. 15, the horizontal distance is 4.0 divisions. The **TIME/DIV** setting is 2 µs. The rise time is calculated as follows:

Rise Time = 4.0 (div) x 2 (µs/div) = 8 µs

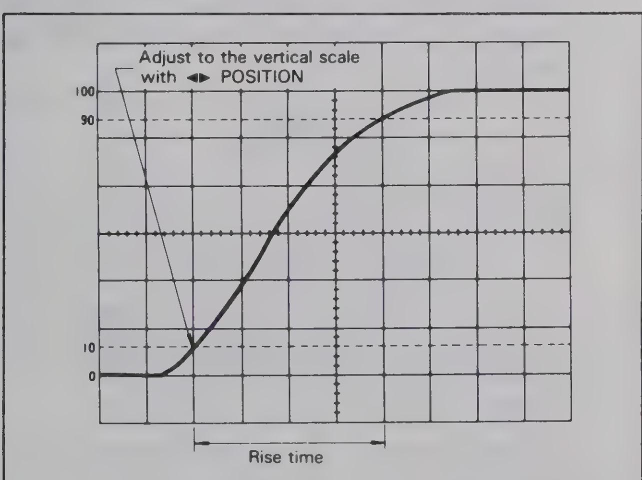

Fig. 15. Rise Time and Fall Time Measurement.

Method No. 2:
(Refer to Fig. 16)

The following step can be substituted for step 3 in method No. 1:

Use the ◄► **POS** control to set the 10% point to coincide with the center vertical graduation line and measure the horizontal distance to the point of the intersection of the waveform with the center horizontal line. Let this distance be D_1. Next, adjust the waveform position so that the 90% point coincides with the vertical centerline and measure the distance from that line to the intersection of the waveform with the horizontal centerline. Let this distance be D_2. The total horizontal distance is D_1 plus D_2.

The following equation summarizes the measurement:

Rise Time = $(D_1 + D_2)$ x **TIME/DIV**

(x 1/10 if **X10 MAG** is used)

For the example shown in Fig. 16, D_1 is 1.8 divisions and D_2 is 2.2 divisions. If the **TIME/DIV** setting is 2 µs, the rise time is calculated as follows:

Rise Time = (1.8 + 2.2) x 2 (µs/div) = 8 µs

NOTE
See APPENDIX I for important rise and fall time considerations.

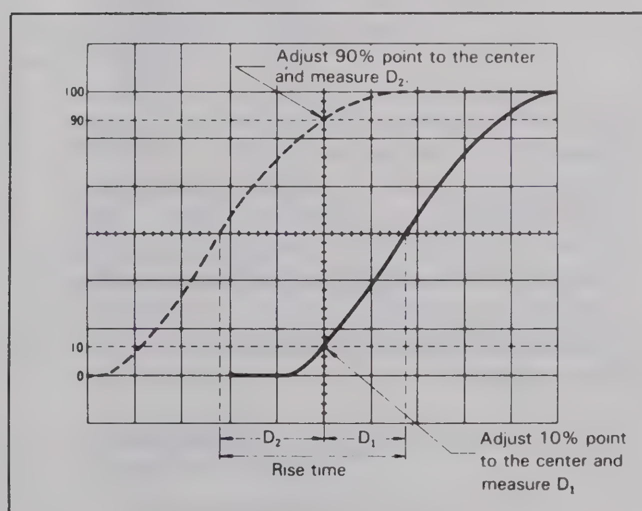

Fig. 16. Rise Time and Fall Time Measurement.

TIME DIFFERENCE MEASUREMENTS
(Refer to Fig. 17)

This procedure is useful in measurement of time difference between signals that are synchronized to one another but skewed in time.

1. Apply the two signals to the **CH 1 (X)** and **CH 2 (Y)** input jacks and select the dual-trace display mode.

2. Select the faster of the two signals as the **TRIG SOURCE** and use the **VOLTS/DIV** and **TIME/DIV** controls to obtain an easily observed display.

3. Use the ⇕ **POS** controls to superimpose both waveforms to intersect the center horizontal graduation line as shown in Fig. 17. Use the ◀▶ **POS** control to set the reference signal coincident with one of the vertical graduation lines.

4. Measure the horizontal distance between the two signals and multiply this distance (in divisions) by the **TIME/DIV** setting. If **X10 MAG** is used, multiply this again by 1/10.

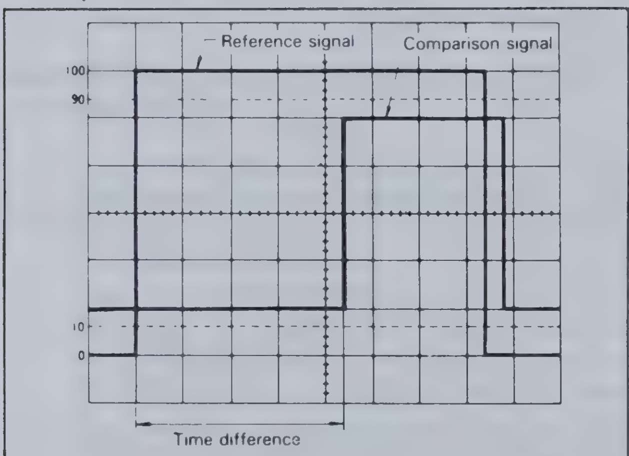

Fig. 17. Time Difference Measurement.

The measurement is summarized by the following equation:

Time = Hor div x **TIME/DIV**

(x 1/10 if **X10 MAG** is used)

For the example shown in Fig. 17, the horizontal distance measured is 4.4 divisions. If the **TIME/DIV** is 0.2 ms and **X10 MAG** is not used, the time difference is calculated as follows:

Time = 4.4 (div) x 0.2 (ms/div)

= 0.88 ms or 880 μs

PHASE DIFFERENCE MEASUREMENTS

Method No. 1
(Refer to Fig. 18)

This procedure is useful in measuring the phase difference of signals of the same frequency.

1. Apply the two signals to the **CH 1 (X)** and **CH 2 (Y)** input jacks, selecting the dual-trace display mode.

2. Set the **TRIG SOURCE** switch to the signal which is leading in phase and use the **VOLTS/DIV** controls to adjust the two waveforms so they are equal in amplitude.

3. Use the ⇕ **POS** controls to position the waveforms in the vertical center of the screen. Use the **TIME/DIV** and **SWEEP/VAR** controls to adjust the display so one cycle of the reference signal occupies 8 divisions horizontally (see Fig. 18). The trigger **LEVEL** and ◀▶ **POS** controls are also useful in achieving this display. The display should be as shown in Fig. 18, where one division now represents 45° in phase.

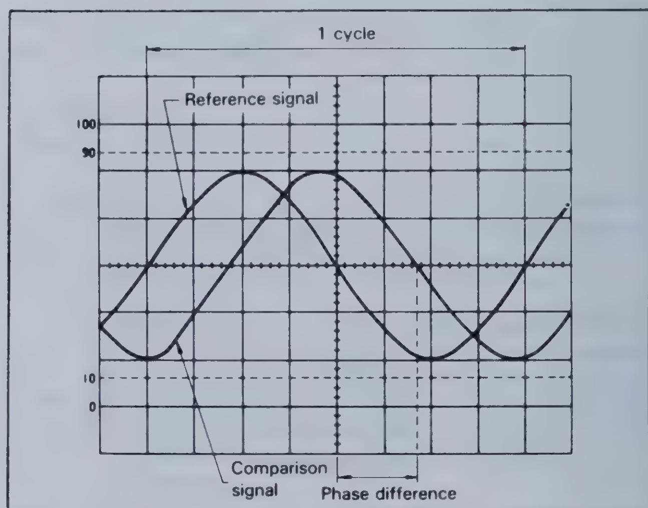

Fig. 18. Phase Difference Measurement.

4. Measure the horizontal distance between corresponding points on the two waveforms. Multiply the distance (in divisions) times 45° per division to obtain the phase difference.

The measurement is summarized by the following equation:

$$\text{Phase difference} = \text{Hor div} \times 45^\circ/\text{div}$$

For the example shown in Fig. 18, the horizontal distance is 1.7 divisions. Thus, the phase difference is calculated as follows:

$$\text{Phase difference} = 1.7 \times 45^\circ/\text{div} = 76.5^\circ$$

Method No. 2
(Refer to Fig. 19)

The above procedure allows 45° per division, which may not give the desired accuracy for small phase differences.

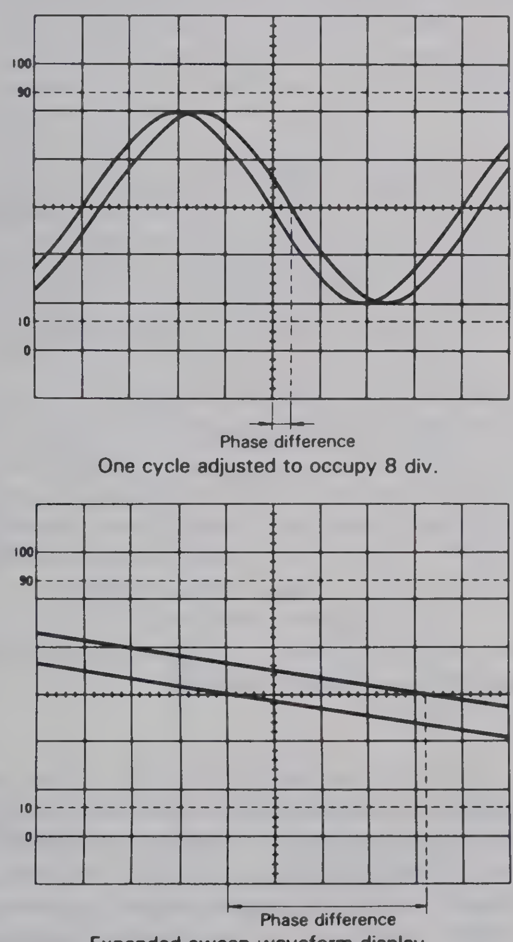

Fig. 19. Measuring Small Phase Difference.

If greater accuracy is required, the **TIME/DIV** setting may be changed to expand the display as shown in Fig. 19, but the **SWEEP/VAR** setting must not be touched. If necessary, the **TRIG LEVEL** control may be readjusted. For this type of operation, the relationship of one division to 45° no longer holds. Instead the following equation must be used:

$$\text{Phase diff} = \text{Hor div} \times 45^\circ/\text{div} \times \frac{A}{B}$$

Where:
A = New **TIME/DIV** setting.
B = Original **TIME/DIV** setting.

A simpler method of obtaining more accuracy quickly is to simply use **X10 MAG** for a scale factor of 4.5°/division.

RELATIVE MEASUREMENTS

If the amplitude and period of some reference signal are known, an unknown signal may be measured for amplitude and period without the volts/div and **SWEEP/VAR** controls set to **CAL.** The measurement is made in units relative to the reference signal.

Relative Voltage Measurements
(Refer to Fig. 20)

1. Apply the reference signal to the input jack and adjust the display for a normal waveform display. Adjust the **VOLTS/DIV**, volts/div **VAR**, and **SWEEP/VAR** controls so that the amplitude of the reference signal occupies a fixed number of divisions. After adjusting, be sure not to disturb the setting of the volts/div **VAR** control.

2. Calculate the vertical calibration coefficient as follows:

$$\text{vertical coefficient} = \frac{C}{D \times E}$$

Where:
C = Amplitude of reference signal (in volts).
D = Amplitude of reference signal (in divisions).
E = **VOLTS/DIV** setting.

3. Remove the reference signal and apply the unknown signal to the input jack, using only the **VOLTS/DIV** control to adjust the amplitude for easy observation (do not disturb the volts/div **VAR** setting).

4. Measure the amplitude of the displayed waveform, in divisions. Multiply the number of divisions by the **VOLTS/DIV** setting and the vertical coefficient from above to find the value of the unknown voltage.

The measurement is summarized by the following equation:

Unknown Voltage = Vert div x **VOLTS/DIV**

x vert coefficient

For the example shown in Fig. 20, the **VAR** control is adjusted so the amplitude of the reference signal is 4 divisions. If the reference signal is 2.0 V p-p, and the **VOLTS/DIV** setting is 1 V, the vertical coefficient is 0.5; which was calculated as follows:

$$\text{vertical coefficient} = \frac{2\ (\text{V})}{4\ (\text{div})\ \times\ 1\ (\text{V/div})}$$

$$= 0.5$$

For the example shown in Fig. 20, the amplitude of the unknown signal is 3 divisions, and the previously calculated vertical coefficient is 0.5. If the **VOLTS/DIV** setting is 5 V, the unknown signal is 7.5 V p-p; which was calculated as follows:

Unknown Voltage =

3 (div) x 5 (V/div) x 0.5 (vert coef)

= 7.5 V

NOTE

It is preferable that the reference voltage be the peak-to-peak value, as in the previous example. The measurement holds true for all waveforms if a p-p reference is used. It is also possible to use an rms value for the reference voltage. The unknown voltage value will also be in rms, but the measurement holds true only if both the reference and unknown signals are undistorted sine waves.

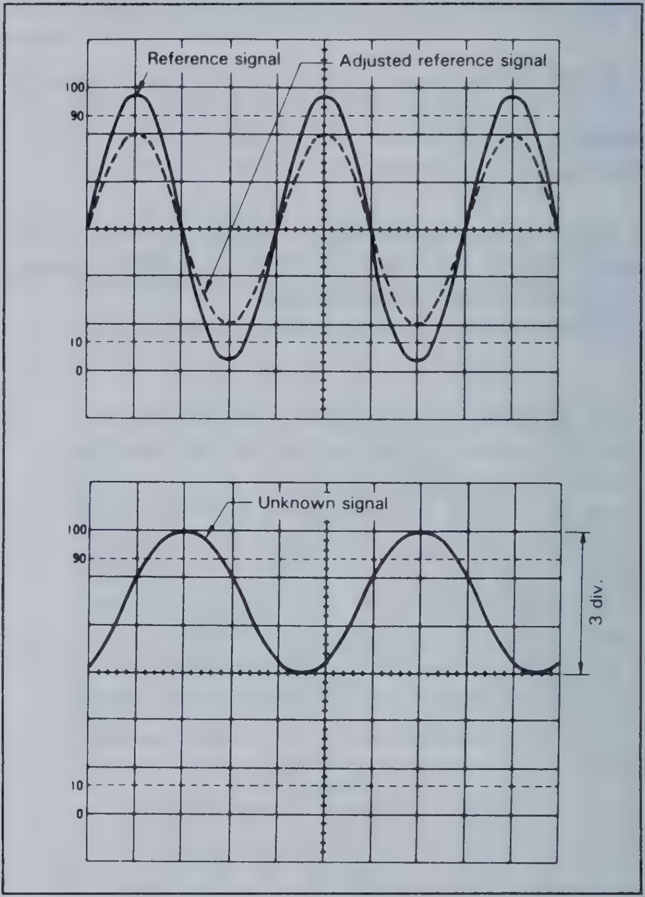

Fig. 20. Voltage Measurement, Relative Method.

Relative Period Measurements
(Refer to Fig. 21)

1. Apply the reference signal to the input jack and adjust the display for a normal waveform display. Using the **TIME/DIV** and **SWEEP/VAR** controls, adjust one cycle of the reference signal to occupy a fixed number of horizontal divisions. After this is done, be sure not to disturb the **SWEEP/VAR** control setting.

2. Calculate the sweep (horizontal) calibration coefficient using the following equation:

$$\text{Sweep coefficient} = \frac{F}{G \times H}$$

Where:

F = Period of reference signal (seconds).
G = Horizontal width of reference signal (divisions).
H = **TIME/DIV** setting.

3. Remove the reference signal and apply the unknown signal to the input jack, using only the **TIME/DIV** control to adjust the width of the display (do not disturb the **SWEEP/VAR** setting).

4. Measure the width of one cycle of the displayed waveform, in divisions. Multiply the number of divisions by the **TIME/DIV** setting and the sweep coefficient from above to find the period of the unknown waveform.

The measurement is summarized by the following equation:

Unknown Period = Horizontal divisions x

TIME/DIV x sweep coefficient

For the example in Fig. 21A, the **SWEEP/VAR** control is adjusted so the reference signal occupies 5 horizontal divisions. If the reference signal is 1.75 kHz, and the **TIME/DIV** control is 0.1 ms, the sweep coefficient is calculated as follows:

$$\text{sweep coefficient} = \frac{1.75\ \text{kHz}^{-1}}{5\ (\text{div}) \times 0.1\ (\text{ms/div})}$$

$$= 1.143$$

For the example in Fig. 21B, the width of the unknown signal is 7 divisions, and the previously calculated sweep coefficient is 1.143. If the **TIME/DIV** setting is 0.2 ms, the period is calculated as follows:

Unknown Period =

7 (div) x 0.2 (ms/div) x 1.143 (sweep coef)

= 1.6 ms

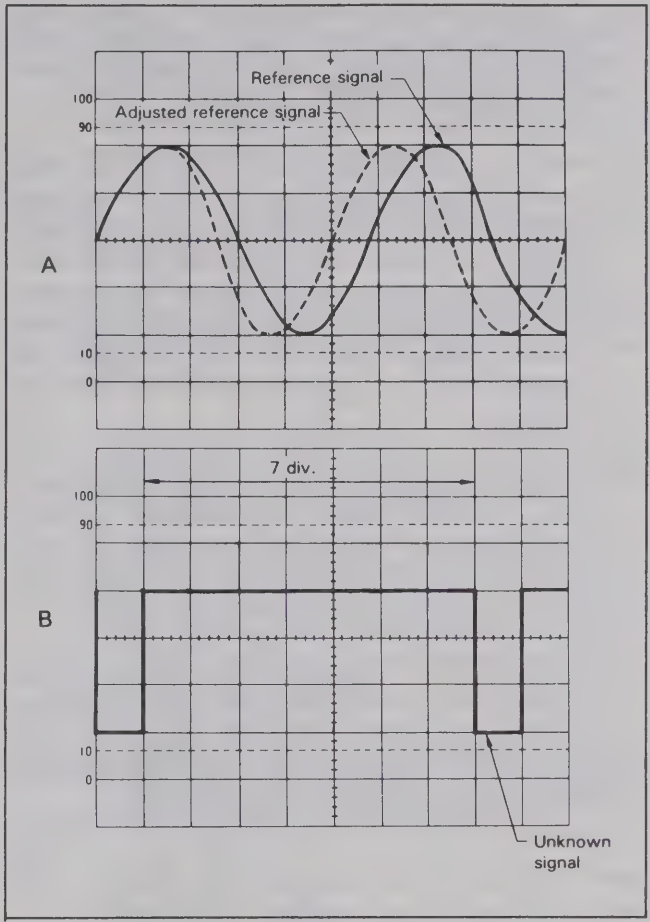

Fig. 21. Period Measurement, Relative Method.

X-Y MODE APPLICATIONS

Phase Measurements

(Refer to Fig. 22)

A dual-trace method of phase measurement was previously described. A second method of phase measurement requires calculations based on the Lissajous patterns obtained using X-Y operation. Distortion due to non-linear amplification can also be displayed.

A sine wave is applied to the audio circuit being tested. The same sine wave is also applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting waveform.

1. Using an audio generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.

2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may first be observed on the oscilloscope with normal sweep operation. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.

3. Connect channel 1 to the input and channel 2 to the output of the test circuit. Set channel 1 and 2 gain controls for exactly the same amplitude waveform on the display in normal sweep operation.

4. Select X-Y operation by setting the **TIME/DIV** control fully counterclockwise (**X-Y**), the **TRIG SOURCE** switch to the **CH 1/X-Y** position, and the **VERT MODE** switch to the **CH 2/X-Y** position.

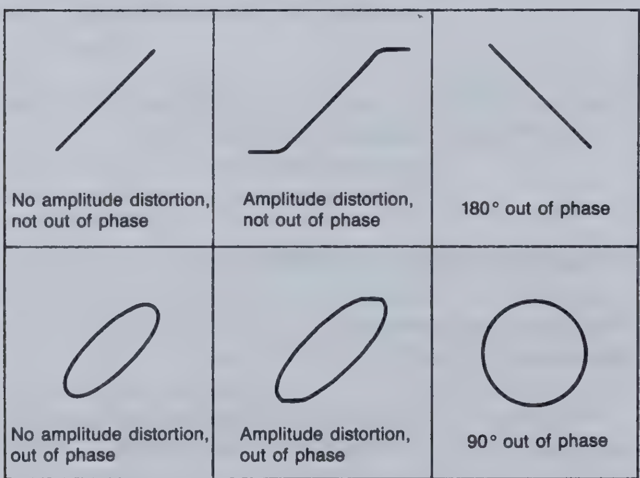

Fig. 22. Typical X-Y Phase Measurement Displays.

5. If necessary, repeat step 3, readjusting the channel 1 and 2 gain controls for a suitable viewing size. Some typical results are shown in Fig. 22.

If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is at a 45° angle. A 90° phase shift produces a circular oscilloscope pattern. Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Fig. 23.

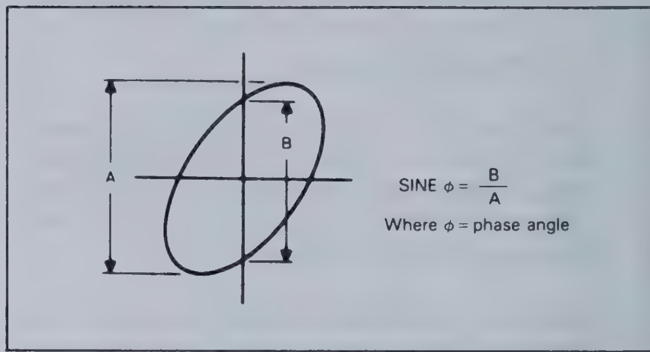

Fig. 23. Phase Measurement, X-Y Operation.

Frequency Response Measurements
(Refer to Fig. 24)

A sweep generator and the X-Y mode of this oscilloscope may be used to measure the audio or rf frequency response of an active or passive device up to 40 MHz, such as an amplifier, band pass filter, coupling network, etc.

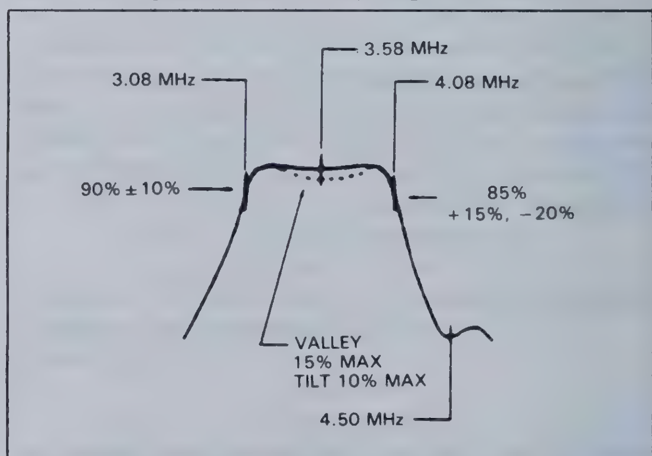

Fig. 24. Frequency Response Measurement.

1. Connect the audio or rf output of the sweep generator to the input of the circuit under test and the output of the test circuit to channel 1 (vertical axis) of the oscilloscope. A demodulator probe will give a "text book" frequency response display as shown in Fig. 24, but a stand-

ard probe can be used which will result in an envelope display.

2. Connect the sweep ramp voltage of the sweep generator to the channel 2 input of the oscilloscope.

3. Set the **TIME/DIV** control to the **X-Y** position (fully counterclockwise), the **TRIG SOURCE** switch to the **CH 1/X-Y** position, the **VERT MODE** switch to the **CH 2/X-Y** position, and adjust the channel 1 and 2 controls for a suitable viewing size.

EXTERNAL HORIZONTAL SWEEP APPLICATIONS
(Refer to Fig. 25 and 26)

The **EXT** Horizontal operating mode allows the Model 1541A oscilloscope to be used to view a frequency response sweep envelope. Unlike oscilloscopes which have no external sweep input, a frequency response sweep envelope can be synchronized, allowing for a synchronized, usable frequency response display. Typical frequency response envelopes can be viewed as follows (Refer to Fig. 25 for set-up):

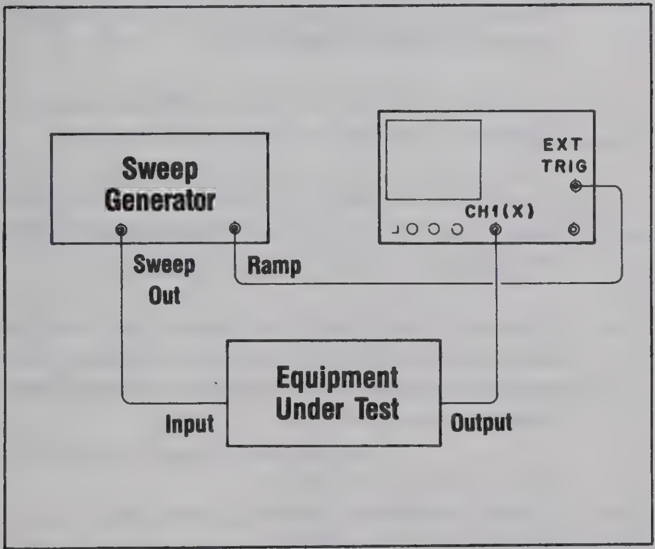

Fig. 25. Frequency Response Set-Up.

1. Set the **TIME/DIV** control on the oscilloscope to the **X-Y** position (fully counterclockwise), the **TRIG SOURCE** switch to the **EXT** position, and the **VERT MODE** switch to the **CH 1** position.

2. Connect a sweep/function generator to the input of the equipment to be tested.

3. Connect the output of the equipment under test to the **CH 1 (X)** input on the oscilloscope.

4. Connect the sweep ramp output of the sweep/function generator to the **EXT TRIG** input on the oscilloscope.

5. Set the sweep/function generator up for the fastest sweep possible (a faster sweep causes the oscilloscope display to "flicker" less) and set the desired start and stop sweep points.

6. Adjust the **CH 1 VOLTS/DIV** control to obtain about five or six vertical divisions of signal at it's highest amplitude.

7. The oscilloscope display should now show a frequency response envelope. The response in Fig. 26 is that of a circuit that has attenuation at lower frequencies.

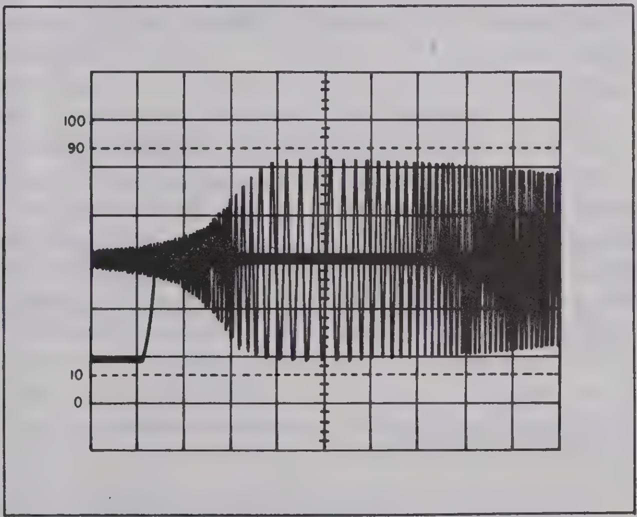

Fig. 26. Frequency Response Envelope.

WARNING

The following instructions are for use by qualified service personnel only. To avoid electrical shock, do not perform any servicing other than contained in the operating instructions unless you are qualified to do so.

High voltage up to 12,000 volts is present when covers are removed and the unit is operating. Remember that high voltage may be retained indefinitely on high voltage capacitors. Also remember that ac line voltage is present on line voltage input circuits any time the instrument is plugged into an ac outlet, even if turned off. Unplug the oscilloscope and discharge high voltage capacitors before performing service procedures.

FUSE REPLACEMENT

If the fuse blows, the pilot light will go out and the oscilloscope will not operate. The fuse should not normally open unless a problem has developed in the unit. Try to determine and correct the cause of the blown fuse, then replace only with the correct value fuse. For 100 V or 120 V operation, use a 0.5 A, 250 V, 3 AG, slow-blow fuse (Dynascan part number 190-251-3-102). For 220 V, 230 V, or 240 V operation, use a 0.3 A, 250 V, 3 AG, slow-blow fuse (Dynscan part number 190-004-9-001). The fuse is located on the rear panel (see Fig. 2).

CASE REMOVAL

To remove the case from the Model 1541A oscilloscope, perform the following steps:

1. Unplug the line cord.
2. Remove the nine screws that secure the top case to the chassis (three along each bottom edge of the top case and three at the back of the top case).
3. Slide the case top back and lift up.
4. To reinstall the case, reverse the procedure.

LINE VOLTAGE SELECTION

The Model 1541A oscilloscope is designed to work with a wide variety of line voltages. These voltages include, 110 V, 120 V, 220 V, 230 V, and 240 V at either 50 or 60 Hz. To select the desired line voltage, perform the following steps:

WARNING

Make sure the oscilloscope is unplugged before converting line voltage.

1. Remove the case by following the instructions in the previous paragraph titled "**CASE REMOVAL**".
2. Locate the line voltage printed circuit board at the back of the oscilloscope.
3. Carefully unplug the 5-pin socket (the largest of the three sockets plugged into the circuit board).
4. Connect the five pin socket to the pin header for the desired line voltage. The voltage range for each of the 5-pin headers is as follows:

   110 V - 99 V to 121 V
   120 V - 108 V to 132 V
   220 V - 198 V to 242 V
   230 V - 207 V to 253 V
   240 V - 216 V to 264 V

5. Be sure to use the proper fuse for the line voltage selected (see the **FUSE REPLACEMENT** paragraph located previ-

ously in this section of the instruction manual). Also, be sure to change fuse information lable if fuse value is changed

PERIODIC ADJUSTMENTS

Screwdriver adjustments only need to be checked and adjusted periodically. Probe compensation, and trace rotation are included in this category. Procedures are given below.

Probe Compensation

1. Connect probes to **CH 1 (X)** and **CH 2 (Y) INPUT** jacks. Repeat procedure for each probe.

2. Touch tip of probe to **CAL** terminal.

3. Adjust oscilloscope controls to display 3 or 4 cycles of **CAL** square wave at 5 or 6 divisions amplitude.

4. Adjust compensation trimmer on probe for optimum square wave (minimum overshoot, rounding off, and tilt). Refer to Fig. 27.

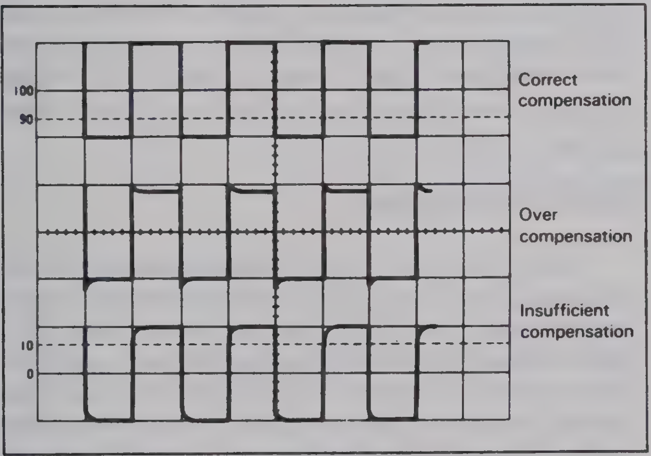

Fig. 27. Probe Compensation Adjustment.

Trace Rotation Adjustment

1. Set oscilloscope controls for a single trace display in **CH 1** mode, and with the channel 1 **AC-GND-DC** switch set to **GND.**

2. Use the channel 1 ♦ **POS** control to position the trace over the center horizontal line on the graticule scale. The trace should be exactly parallel with the horizontal line.

3. Use the **TRACE ROTATION** adjustment on the front panel to eliminate any trace tilt.

CALIBRATION CHECK

A general check of calibration accuracy may be made by displaying the output of the **CAL** terminal on the screen. This terminal provides a square wave of 2.0 V p-p. This signal should produce a displayed waveform amplitude of four divisions at 0.5 V/div sensitivity for both channel 1 and 2 (with probes set for direct). With probes set for 10:1, there should be four divisions amplitude at 50 mV/div sensitivity. The volts/div and **SWEEP/VAR** controls must be set to **CAL** during this check.

*The **CAL** signal may be used only as a general check of calibration accuracy, not as a signal source for performing recalibration adjustments; a signal source of ± 0.3% or better accuracy is required for calibration adjustments.*

INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, many customers prefer to rely upon **B & K-Precision** for this service. We maintain a network of **B & K-Precision** authorized service agencies for this purpose. To use this service, even if the oscilloscope is no longer under warranty, follow the instructions given in the WARRANTY SERVICE INSTRUCTION portion of this manual. There is a nominal charge for instruments out of warranty.

APPENDIX I

IMPORTANT CONSIDERATIONS FOR RISE TIME AND FALL TIME MEASUREMENTS

Error In Observed Measurement

The observed rise time (or fall time) as seen on the CRT is actually the cascaded rise time of the pulse being measured and the oscilloscope's own risetime. The two rise times are combined in square law addition as follows:

$$T_{observed} = \sqrt{(T_{pulse})^2 + (T_{scope})^2}$$

The effect of the oscilloscope's rise time is almost negligible when its rise time is at least 3 times as fast as that of the pulse being measured. Thus, slower rise times may be measured directly from the CRT. However, for faster rise time pulses, an error is introduced that increases progressively as the pulse rise time approaches that of the oscilloscope. Accurate measurements can still be obtained by calculation as described below.

Direct Measurements

The Model 1541A Oscilloscope has a rated rise time of 8.8 ns at 5 mV/div and higher sensitivity. Thus, pulse rise times of about 27 ns or greater can be measured directly. Most rise times are measured at the fastest sweep speed and using **X10 MAG**. For Model 1541A, this sweep rate is 20 ns/div. A rise time measurement of less than about 2 divisions should be calculated.

With **X5 MAG** selected (1 mV/div and 2 mV/div sensitivity), the rated rise time is increased to 17.5 ns. Pulse rise times must be at least 60 ns (for direct measurement on these ranges). Because of this, the **X5 MAG** mode of operation should be avoided for rise time measurements if possible.

Calculated Measurements

For observed rise times of less than 27 ns, the pulse rise time should be calculated to eliminate the error introduced by the cascaded oscilloscope rise time. Calculate pulse rise time as follows:

$$T_{pulse} = \sqrt{(T_{observed})^2 - (T_{scope})^2}$$

Limits Of Measurement

Measurements of pulse rise times that are faster than the oscilloscope's rated rise time are not recommended because a very small reading error introduces significant error into the calculation. This limit is reached when the "observed" rise time is about 1.3 times greater than the scope's rated rise time, about 12 ns.

Probe Considerations

For fast rise time measurements which approach the limits of measurement, direct connection via 50 Ω coaxial cable and 50 Ω termination is recommended where possible. When a probe is used, its rise time is also cascaded in square law addition. Thus the probe rating should be considerably faster than the oscilloscope if it is to be disregarded in the measurement.

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.

2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Dynascan Corporation
Factory Service Operations
6460 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-8870
Telex: 25-3475

Also use this address for technical inquiries
and replacement parts orders.

LIMITED TWO-YEAR WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of two years from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

To obtain warranty coverage in the U.S.A., this product must be registered by completing and mailing the enclosed warranty registration card to DYNASCAN, **B & K-Precision**, 6460 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 6460 West Cortland Street, Chicago, Illinois 60635, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the **B & K-Precision** products which it sells.

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DYNASCAN CORPORATION

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